SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXXVIII
NUMBER 2281

* NEW YORK, SEPTEMBER 20, 1919 *

10 CENTS A COPY
$5.00 A YEAR

Published weekly. Entered as second class matter December 15, 1887, at the Post Office at New York, N. Y., under Act of March 3, 1879

A transportable combination of power-plant, cables, and mast that does the "jerking" and loading work formerly requiring many teams and hands in the lumbering field

LOG-JERKING MACHINE

Cold Storage of Food—II*

A Critical Consideration of the Physical Changes in Meat Preserved by Cold Storage

By Ingvar Jörgensen and Walter Stiles, Dept. Industrial Research, London

In our previous article [Part I] we dealt with the cold storage of fruit in order to demonstrate the type of cold storage in which no physical alterations of the material take place. We indicated that at present the cold storage of fruit does not allow much variation in method, but it should be realized that the main hindrance at present is the elementary state of plant physiological knowledge. When the physico-chemical aspect of metabolism in fruits has been subjected to an adequate investigation it will no doubt be found that considerable variation will be possible in regard to industrial methods.

In the present article we propose to consider especially the cold storage of meat, a question of the highest industrial importance and scientific interest, which introduces us to the second class of substances, those which can be preserved in the frozen condition. Nevertheless, large quantities of meat are also preserved at temperatures about 0°C., by which no great change in physical state is produced.

The possibility of the preservation of flesh foods by the use of low temperatures has been recognized and employed to some extent for hundreds and thousands of years by the inhabitants of cold countries, where by freezing meat and game in ice under natural conditions these food substances have been preserved for long periods.

The extreme case of this is that of the mammoth[1] and other prehistoric animals, which are still found preserved intact in a mummified condition. It is, however, only in recent years that the industrial possibilities of preserving meat by the use of low temperatures were realized, and the industrial development naturally only took place when it became possible to construct refrigerating engines for the production of the low temperatures necessary.

The principles of refrigerating machinery were worked out in the middle decades of the last century. It is outside the scope of these articles to deal with the great amount of work which led to the present development of this machinery.[2] The first vapor compressing machine appears to be due to Jacob Perkins, who patented an apparatus in 1834; but the first machine of this type which was of industrial importance was constructed by James Harrison in 1857, the machine working with ether. According to French writers[3] it was Charles Tellier who first used the refrigerating machine for the preservation of meat during transport. In 1868 he made an attempt to carry meat at a temperature of + 2° to 0°C. from London to the river Plate, but this attempt failed owing to a break-down in the machinery. Financial difficulties consequent on the war of 1870 prevented an immediate repetition of the experiment, although in 1873 Tellier succeeded in demonstrating to the Académie des Sciences in Paris that the keeping qualities of meat were enhanced by lowering the temperature to 2°C. to 0°C., and that the food value was not lessened. However, in 1876 he showed the possibility of transporting meat in cold storage across the Atlantic by carrying thus ten carcasses of beef, twelve sheep, two calves, one pig and fifty birds from Rouen to Buenos Ayres, it being alleged that the cargo arrived in a perfect state. Unfortunately, the return journey was a failure. The twenty-one tons of meat carried were spoilt; whether this was due to the incapacity of the plant to deal with so much material is not quite clear.

Circumstances led to the withdrawal of Tellier from the enterprise, but the possibility of transporting perishable food products for long distances by means of cold storage had been demonstrated.

The French work on Tellier says:

"La voie était ouverte aux initiatives, pour récolter l'ample moisson semée par le génie français. Qui allait en profiter?

"Ce furent les Anglais, qui, avec leur ténacité et leur splendide esprit de suite, reprirent la question."[4]

The significance of Tellier's experiment lies in the fact that a clear demonstration was made of the possibility of transporting food substances over long distances and that these distances might be unlimited. It is only natural that such a realization should cause considerable commotion in the financial and commercial world. It is regrettable that the scientific aspect should have been entirely neglected, because development indicates clearly that the progress has been determined by successful financial ventures, and not on account of advances in science, and this unfortunate lack of balance between commercial and scientific development is probably responsible for the stagnation in the subject.

This may perhaps be better realized if one compares the meat industry with an industry originating at much the same time, the electrical industry. The basis of this industry is entirely the work of a few distinguished scientific men, but the whole development in the electrical industry gives clear evidence of an harmonious interplay between scientific work and financial venture.

The transport of meat in the *frozen* condition as distinguished from the merely *chilled* state, commenced in 1879, when the first shipment of frozen mutton was sent to Britain from New Zealand.

Yet, although the importation of frozen meat characterizes the beginning of an entirely new epoch, it was initiated rather as a successful venture, and further development has depended on further successful ventures. Failures led, not to scientific investigations into the causes of failure, but to the banning of the experiment.

In the introduction of freezing as a method of food preservation, a method which involved physical changes of state in the material preserved, a scientific investigation should have been undertaken at once to determine how far the changes taking place on freezing could be made reversible on thawing, as on this would depend the completeness with which the material would regain its original fresh condition. By research on these lines it should have been settled what were the differences between chilled and frozen beef. As an example of how difficult it has been for new ideas to penetrate the indifference of a flourishing trade we may quote an experiment made by the firm of J. & E. Hall, of Dartford, on the application of brine freezing to the preservation of meat, a question which in the last few years has attracted much attention on the continent of Europe. As this British pioneer work has been completely neglected, we may be justified in giving here a brief reference to it. We are indebted to Mr. Hesketh for the following extracts from his diary:

"*January* 26, 1889.—An experiment was made on freezing mutton by direct immersion in brine made by common salt and water and kept at a very low temperature by a CO_2 refrigerating machine.

"*January* 28, 1889.—Mr. Marcet and Mr. Hasketh had an interview with Mr. William Cook, the London partner of Sansinenas, then one of the most important meat freezers at Buenos Ayres, at whose works Mr. Hesketh spent some six months in 1886.

"*January* 29, 1889.—Messrs. Hesketh, Godfrey and Marcet, the then partners in J. & E. Hall, lunched at the works off the mutton which had been frozen by immersion, which proved very good."

This application of brine freezing to meat as an industrial process was patented by Messrs. Hesketh and Marcet[5] in 1889, but the utter lack of interest in this country and elsewhere on the part of those concerned in the preservation of meat debarred any development of the process. So complete, indeed, has been the neglect of this early work that in a recent German paper[6] dealing with the freezing of meat in a salt solution the only reference is to Ottesen of Copenhagen, whose patent on this question[7] was not filed until as recently as 1912.

Even the Committee on Food Standards of the Association of Official Agricultural Chemists, in their definitions of meat, do not distinguish between chilled and frozen meat, since their third definition is, "Cold storage meat is meat from animals recently slaughtered and preserved by refrigeration until delivered to the consumer."[8] In commenting on this definition, W. D. Richardson points out how unsatisfactory it is. He says: "The every-day distinction and scientific distinction also should be made between chilled meat and frozen meat, the former being held at temperatures of a few degrees above the freezing point until delivered to the consumer, and the latter in the solid frozen condition."[8]

It is also interesting to note that there is apparently no other official test for frozen meat than the examination of the blood, the red corpuscles of which have undergone hæmolysis in the case of frozen meat.

Nevertheless, in spite of the fact that the development of the cold storage industry, in so far as it concerns meat, has not been based on scientific research, a certain amount of scientific information having a bearing on the question has been collected. The principal constituents of meat, chemically considered, are water, proteins and fats. The lean of beef and mutton contains about 75 per cent of water. Of the remaining 25 per cent, by far the greater proportion is protein, this amounting sometimes to 20 per cent of the total weight in beef, the remaining 5 per cent being composed of water-soluble organic substances (about 4 per cent) and inorganic salts about 1 per cent of the whole carcass. The relative amount of protein varies considerably in different individuals, especially in relation to the amount of fat, which in mutton may amount to three times the weight of nitrogenous substances.[9] Thus it is to be expected that the problem of preserving meat at low temperatures just above the freezing-point presents difficulties different from those in fruits, where the great proportion of the dry matter is carbohydrate.

The lean part of meat is composed of muscle fibres which are narrow and thread-like, the bundles of fibers being penetrated and supported by the connective tissue, which contains the nerves and blood-vessels. After the death of the animal the first change which takes place is the setting in of the condition called *rigor mortis*, during which the muscle fibers lose their contractility. The soluble proteins coagulate, lactic acid is produced and the reaction of the meat changes from alkaline to acid. Later, the condition of *rigor mortis* passes away as the muscle tissue undergoes a fresh change, that known as "ripening," in which the muscle tissue relaxes, the meat at the same time becoming more tender. This change is brought about by proteolytic enzymes in the meat, and is to be regarded as a process of auto-digestion. At the same time, as the process of ripening is proceeding in the lean, other changes are proceeding in the fat. This latter undergoes hydrolysis if water is present, by which fatty acids and glycerol are produced, while, in presence of oxygen as well, lower fatty acids, aldehydes and other volatile substances are formed, producing the unpleasant condition known as rancidity.

These changes take place slowly at ordinary temperatures if the necessary external conditions (water and oxygen) are present, as under ordinary circumstances they always are. At temperatures of from 1° to 3°C. the maximum "ripening" effect in sides and quarters of beef is reached in from fifteen to twenty-one days, when a secondary complication has not affected the meat to any extent. This complication results from the invasion of the meat by micro-organisms (bacteria and moulds). The progressive decomposition of lean meat brought about by micro-organisms is that which is generally responsible for its becoming spoilt, the changes being described as putrefaction or decay according as they are produced in absence or presence of oxygen. The former changes are characterized by the production of unpleasant smelling substances; these are practically absent in the latter, but much carbon dioxide is given off.

Hydrolysis of fat may also be brought about by bacterial action, but is usually negligible.

The penetration of bacteria into meat takes place in two ways. There is a gradual and regular progress inwards of the original surface colonies, and a more rapid and irregular penetration along the connective tissue. In the case of the former, penetration at a temperature of about 2°C. is from 0.2 mm. to 1 cm. in thirty days; naturally the distance of penetration increases with the time stored.

(*Continued on page 192*)

*Reprinted from *Science Progress* (London). Part I appeared in No. 2279 of this SUPPLEMENT Sept. 6, 1919.

[1] C. Lyell, *Principles of Geology*, vol. *1*, p. 182, London, 1872.

[2] See J. A. Ewing, *The Mechanical Production of Cold*, Cambridge, 1908.

[3] *E. g.* E. H. Amagat and L. Décombe. *La Statique des Fluides. La Liquéfaction des Gaz et l'Industrie du Froid*, Paris and Liège, 1917.

[4] *Compte rendu officiel de la Manifestation Internationale en l'Honneur de Charles Tellier "Pere du Froid,"* Paris, 1913.

[5] British Patent, No. 6,117, 1889.

[6] R. Plank, "Uber den Einfluss der Gefriergeschwindigkeit auf die histologischen Veränderungen tierischer Gewebe." *Zeitsch. f. allg. Physiol.* 1918, *17*, 221-38.

[7] British Patent, No. 24,244, 1912.

[8] See W. D. Richardson, "Meat and Meat Products," in *Allen's Commercial Organic Analysis*, vol. *8*, p. 261, London, 1913.

[9] See *e. g.* A. D. Hall, "The Book of the Rothamsted Experiments." Second Edition, pp. 250-54, London, 1917; also W. D. Richardson in *Allen's Commercial Organic Analysis*, vol 8, pp. 262-7, London, 1913.

Effect of Light on Living Organism[*]

Study of Light-Sense Apparatus and Its Substance in Its Reaction to Light Suggests Photo-Catalysis

By Fritz Schanz, Dresden[1]

THE albumens are photo-sensitive and light changes the more readily soluble among them into more difficultly soluble forms. There are numerous substances in nature which act like catalyzers to accelerate or retard these transformation processes of the albumens, i. e. as positive and negative photo-catalyzers.[2] The most widespread of these is chlorophyll. If we place albumen solutions in direct sunlight we can readily observe, by employing the usual methods for separating the albumens from the globulins, how the globulins in the solution increase under the effect of light at the expense of the albumens. If chlorophyll be added to the albumen solution in various stronger degrees of concentration, we perceive that the transformation of the albumen becomes much more intensive and that it increases in proportion to the amount of chlorophyll. The derivative of chlorophyll known as phyllo-porphyrin acts in the same manner. This latter substance is believed to closely resemble haemato-porphyrin in its chemical constitution. The latter substance is one of the most powerful photo-catalyzers known and is the one which has been most extensively studied. Haemato-porphyrin is an iron-free distintegration product of the blood pigment, haemoglobin. It is a pigment having a beautiful red fluorescence and it is soluble in acids with the production of a red color and in alkalies with that of a brownish color. In a dilution of 1:80,000 it is capable of killing cultures of paramecia in the light of a cloudy winter day. It is also capable, in the presence of light, of dissolving the red blood corpuscles of the most various kinds of animals. It has no effect in the dark, however. It is active only in the presence of light. The reason for this is not, as might be supposed, that light causes the formation of a substance which acts as a poison. On the contrary, the solutions of this substance can be exposed to light for a long period without becoming a bit more poisonous than those not so exposed.

By making use of this substance the warm-blooded animals can be rendered sensitive to light in the highest degree. If small quantities of it be injected into white mice the latter show no signs of injury so long as they remain unexposed to the light. But Hausmann found that even the diffused daylight of an early spring day in Vienna was sufficient to produce death in animals which had been previously so injected. Neither the haemato-porphyrin alone nor light alone, even of much greater intensity, is capable of injuring the animals; the injury is caused by the combined effect of the two. The acutest form of this malady produces a deep narcosis in the animal in the course of a few minutes, after which death rapidly ensues. Hausmann gave this condition the name of "light-stroke" and he is of opinion that a great many cases of sunstroke are connected with similar processes of sensitivization. The acute form occurs when the animals are exposed to an intensive illumination after the injection of a small quantity of the pigment. But the same condition is produced when the illumination (non-intensive) occurs not too long after the injection of larger quantities. In this case there are seen intensive phenomena of itching such as scratching, rubbing and rolling almost immediately after the exposure to the light begins; there is also a reddening of the ears and a marked aversion to light. After the lapse of two or three hours the animals, which appear somewhat swollen, often die with symptoms resembling those of tetanus.

The sub-cutaneous form, when the intensive illumination begins after a longer lapse of time—about a week—after the injection, or else when the animal experimented on is exposed very soon after the reception of the pigment merely to ordinary diffused and not over-bright daylight. This variety of the malady, which lasts from half a day to two days, is accompanied with an uncommonly marked oedema of the surface of the animal's body. The mice appear greatly swollen and formless, the ears are thrust stiffly forward in a crescent shape, and the eyes are usually entirely gummed together. If they recover from this sub-cutaneous form of the disease they very often suffer from a necrosis of the ears, which mostly fall off, as well as from a characteristic loss of hair.

Meyer-Betz[3] tested the photo-catalytic effect of haemato-porphyrin upon human beings by an experiment made upon himself. Traces of this pigment are found in all human urine. MacMunn found it in the integument of snails as also in the brownish-red starfish. He also discovered it in the porphyry-brown stripes on the back of earth worms. According to this, this pigment seems not to be rare in the lower animals. Grauben and Finsen also made the discovery that the earth worm is sensitive to light. The albumens of earth worms undergo the same alteration through light as do other albumens—out of the easily soluble ones more difficultly soluble ones are formed. It is quite conceivable that such an alteration would be sufficient to produce an impression of light. However, there is in the dorsal cord of the earth worm a photo-catalyzer which is capable of increasing the effect of light very intensively. The dorsal cord is the light sense-organ of the earth worm. The rays effective for haemato-porphyrin lie in the green. Earth worms avoid light and take refuge in the red, i. e. in that part of the radiation which is not absorbed by this pigment.

Haemato-porphyrin is one of the best known photo-catalyzers but there are many others, and we must distinguish between those which are endogenous and those which are exogenous. The first are formed in the organism itself (chlorophyll, haemato-porphyrin, phyllo-porphyrin, lactic acid, grape sugar, urea), while the others are brought to the organism from without and consist especially of inorganic mineral salts which impart a marked sensibility to all organic substances, including the albumens. The pigments which color the integuments of animals are endogenous. In a marine aquarium we admire the gorgeous colors of the fauna and flora at the bottom of the sea. But this colorful vision loses its magnificence even for our color-skilled eyes at a distance of six to eight meters below the surface of the water. As the depth of water increases the colors of the light which penetrates alter correspondingly. The red and yellow rays are absorbed to a much greater degree than the green and blue. At a depth of six to eight meters the red and yellow light is absorbed and only the blue and green remain. The colors of the organisms look yellow and red to us because they absorb the green and blue light. In other words the integument of these organisms is colored red and yellow because it thereby becomes able to absorb the light which penetrates to these depths and make use of it for its own benefit. These pigments, therefore, are photo-catalyzers in the same way the haemato-porphyrin in the dorsal cord of the earth worm is. The gay hues of nature have been looked upon as devices for securing protection or as means of attraction. It has been supposed, for example, that the colors of flowers attracted insects, and on the other hand that gaudy colors protect animals against certain enemies. But such explanations can be of no avail as far as the flora and fauna upon the bottom of the sea are concerned. All these creatures lose their splendid coloring, even for our color-sensitive eye, at a depth of six to eight meters. But as far as the dwellers of the sea are concerned the colors cease to matter as a general thing, since these inmates of the water are without exception color blind. As C. v. Hess[4] has shown indubitably a sense of color is possessed only by air dwelling vertebrate animals, while the inmates of the water see everything in shades of gray. Since they perceive only differences in the degree of brightness the most magnificent colors can neither allure nor frighten them. Hence the idea which is still current as to the purpose of color cannot be correct. But when you regard the colors as photo-catalyzers they become of the greatest significance for these organisms.

Let us now examine the colors of the integuments of the fauna and flora living upon the surface of the earth. In the skin of those races of men who are exposed to strong light a dark pigment is formed. This decreases the effect of light upon the albumen. It is a negative photo-catalyzer. Upon the integument of animals we may see the greatest variety of alterations which must be regarded as the effects of light. I will here mention only the strong coloring on the backs of animals. In the kingdom of plants we have the most widespread positive photo-catalyzer in the form of chlorophyll. Organic substances formed by plants themselves likewise act upon their albumens as photo-catalyzers, as do the mineral substances obtained by plants from the earth. . . .[5] From the combined effect of such postive and negative catalyzers albumens will be formed which will vary from each other. The specific albumens will be produced whose peculiarities depend upon the effect of the catalyzers combined in each special case. Thus we obtain albumens which are peculiar to special kinds of plants.

But what is the purpose of the glorious colors found in flowers? It has been thought that they were meant to attract insects and show them the way to the honey cups, i. e. to their food, but this is an entirely wrong belief, for insects, including even bees, are color blind. They see everything in shades of gray. They are capable only of perceiving the degrees of brightness, hence we must seek another explanation for the splendor of our flowers. The colors of blossoms are photo-catalyzers. Certain special rays, apparently the rays which are complementary to the colors of the flowers, are absorbed from the light received from the sun. In the transformation of the albumens this must cause the production of quite specific kinds of albumen. These special albumens are treasured up in the storehouse of the fruit and are carried with the seeds into the new organism and determine its nature.

In animals the whole integument is receptive to the effects of light; in the lower animals the integument forms a light sense apparatus through the fact that it is provided throughout with a photo-catalyzer, as for example, in the case of the ocean fauna and flora cited above. In other animals the light sense-apparatus is localized as in the dorsal cord of the earth worm. In the higher animals the localization has proceeded further and the light sense organ is connected with apparatuses capable of forming images of the surrounding world. Thus we advance to the development of the eye. The retina is formed and becomes the organ for the perception of light. We do not understand the process concerned in this. But we perceive that optic substances such as the optic purple which are decomposed by light, are present in the retina. We are familiar with pigments which inhibit the effect of light. Since we know that the albumens are photo-sensitive we are obliged to believe that the albumens of these sense epithelium cells undergo direct alteration through light, and it is only a step further to believe that the optic substances and the pigment of the retina act in this respect as positive and negative photo-catalyzers. If we can accept this view of the matter we can regard the same photo-catalyzer process, which we observe everywhere in living nature, as forming the basis of the act of vision.

*Translated for SCIENTIFIC AMERICAN SUPPLEMENT from *Meteorological Zeitschrift* (Braunschweig).

[1]Reprinted from *Münchener Mediz. Wochensch.*, 1915, No. 39.

[2]F. Schanz Die Wirkung des Lichtes auf die lebenden Organismen. *Biochem. Zeitschr.* 1915.

[3]D. A. f. Klin. Med. 1913, *112*, 476.

[4]C. v. Hess, Die Entwicklung von Lichtsinn und Farbensinn im Tierreiche. Wiesbaden, 1914.

[5]F. Schanz, Die Wirkung des Lichtes auf die lebenden Organismen. *Biochem. Zeitschr.* 1915.

Progress in the Utilization of Wind Motors

MONSIEUR P. FAYARD has succeeded in designing a type of windmill for power purpose which can be direct coupled to the armature of the dynamo.

The power of a windmill propeller is proportional to its surface, which, in its turn, is proportional to the square of its radius; but the speed of rotation is inversely proportional to this radius. To increase the speed then without reducing the area there is only one way: to diminish the radius and increase the number of propellers.

M. Fayard's experiments showed that by keying the dynamo armature direct to the motor shaft, carrying six propellers sufficiently widely spaced, an apparatus could be obtained satisfying the conditions of efficiency, smooth running, and safety; and capable of charging small accumulators by the aid of an automatic switch.

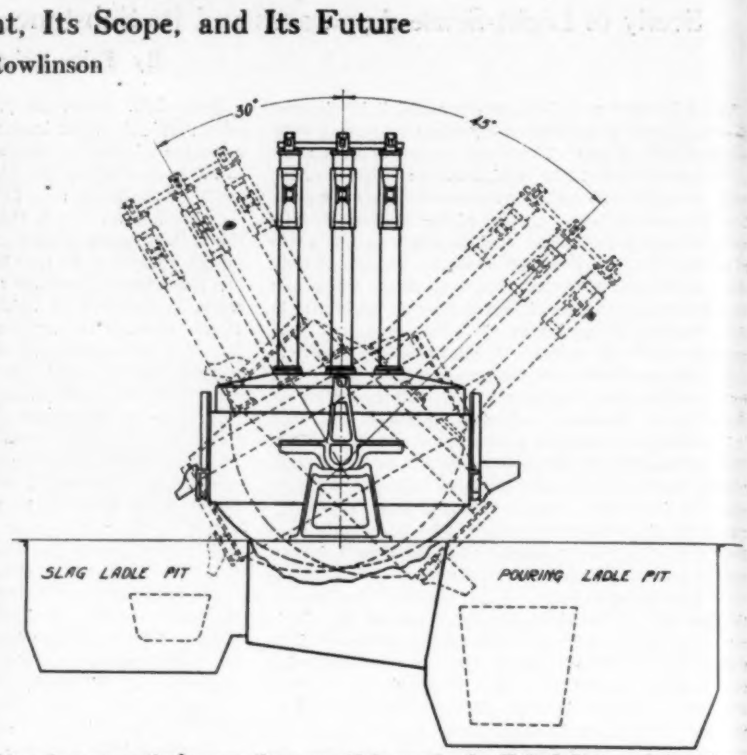
In a great measure this combination gets over the "cube law" of aerodynamics, which the present writer proceeds to explain.

The work produced with a six-screw wind motor is more constant than with the single-screw type. The motor is more rigid and better able to withstand gusts, which do not attack it on the entire area at the same moment. It is stated that a motor of this type, of practical dimensions, having 10 m. of sail area, with screws 1.60 m. diameter, will yield in a wind blowing at 5 to 10 m./sec., a useful work of 5 to 20 hectowatts with a six-pole dynamo of efficiency 0.6.—*La Nature.*

The Electric Furnace—II*

A Survey of Its Development, Its Scope, and Its Future

By F. Rowlinson



A distinctively steel-making furnace invented by an engineer in Pittsburgh. Although comparatively new, there are 12 in use in the United States of America. The three carbon electrodes form the corners of a triangle and project into the circular furnace from its top

The application of the electric furnace to non-ferrous metallurgy has not advanced with the same rapidity as in the case of steel. This is no doubt due to the fact that temperatures in non-ferrous work do not ordinarily rule so high as in ferrous metallurgy. None the less, in regions where fuel is scarce and hydroelectric power is cheap, and also in the refining of volatile metals, the electric furnace is already making headway.

For instance, there are many copper-bearing lands situated remote from fuel supplies, but conveniently near sources of hydroelectric power. Noticeably so is this in certain parts of the United States and Canada, and in Chile and Mexico. The preliminary smelting of copper ores, unlike that of iron ores, utilizes carbonaceous fuel (either in the blast or reverberatory furnace) solely as a source of heat. The fuel plays no chemical part in the metallurgical process. This being the case, there seems no reason why, in such circumstances, thermo-electric methods may not with advantage be utilized in the smelting of these copper ores. The field seems to the writer to be vastly wider than the corresponding ore in iron-ore smelting, and even in districts where hydroelectric power is not available, with the present rate of improvement in steam turbines and gas engines, it will probably be commercially feasible to smelt copper ores in an electric blast furnace. At present this work does not seem to have advanced far beyond the experimental stage, but the investigations hitherto carried out all point to the likelihood of rapid and extensive progress in this direction.

The smelting of lead ores does not seem to offer any great future to the electric furnace; the ease with which these are now smelted by the combustion furnace renders any large scale developments unlikely. Yet for certain of the complex zinc and silver bearing lead ores, the electric furnace would seem to offer advantages, notably in the matter of slags high in zinc.

The greatest application of the electric furnace to non-ferrous metallurgy is, of course, the manufacture of aluminum. The type of furnace, both under the Hall & Héroult patents, is substantially the same, an iron shell lined internally with carbon forming the cathode, the anodes consisting of several grouped carbon blocks above and projecting into the bath. The current is direct (contrary to the usual electric furnace practice) since the action is not only heating, but electrolytic as well. The process, briefly, consists in the electrolysis of purified bauxite in a bath of molten cryolite. The latter, which melts at about 1,000°, is kept liquid solely by the heat generated by the passage of the current. Since aluminum is so situated in the list of metals that all the metallic impurities of the bauxite pass into the aluminum, great care must be taken to purify the bauxite by a preliminary process. Bayer's method, that chiefly used, is very effective, but somewhat costly. A new process now carried out in Savoy offers an interesting development of the use of the electric power. The bauxite is heated in a current of nitrogen by passing it through an electric resistance furnace at a temperature sufficiently high (1,800°-1,900°) to ensure the formation of aluminum nitride. This is afterwards decomposed, forming purified alumina and ammonia—the latter an exceedingly valuable by-product, greatly reducing the cost of manufacture. The preliminary costly but necessary purification of the bauxite before its use in the electrolytic furnace has led to a search for other likely sources of alumina. Most promising of these is the mineral alunite. This is a double sulphate of aluminum and potassium, and although the known supplies are not easily available, the present high price of the potash recoverable along with the alumina, bids fair to make this mineral of considerable importance in the manufacture of aluminum.

Next to aluminum, zinc is the non-ferrous metal most suited to electrical smelting. Unlike aluminum, though zinc is chiefly smelted by the retort process in combustion furnaces—there is no competitive combustion process in the case of aluminum. That zinc can be smelted electrically is well established, but there is one drawback to the successful application of thermo-electric methods which still operates in favor of the older combustion retort process. The latter has numerous and serious disadvantages; chief of these are that this process is of necessity intermittent, that small quantities only can be treated in one retort, and that the calorific efficiency is deplorably low. Now, although the electric zinc smelting furnace is continuous and rapid, treating large quantities per unit internal volume, and calorifically efficient, it has one great metallurgical drawback. For various reasons, chiefly connected with the rapidity of volatilization and the presence of a large percentage of carbon dioxide in the furnace gases, the zinc vapor entering the condensers does not form a liquid, but appears largely as a bluish powder. This seems to consist of zinc particles coated with oxide of zinc (through gaseous oxidation from the carbon dioxide) and silicon or silica. The problem of preventing the formation of this powder seems to have been tackled, but no real solution is forthcoming. Beyond lowering the furnace temperature directly below the electrode (i. e. by adopting a larger cross-sectional electrode-area) and by passing the evolved gases over incandescent carbon, it would hardly be possible at present to minimize this trouble. To eliminate it would necessitate a very full research along the latest lines in physical chemistry, as the factors seem to be pressure, temperature, and the presence of various impurities in the vapors. This problem once solved, there can be small doubt of the great future lying before the electric zinc-smelting furnace.

A further branch of non-ferrous metallurgy in which electric furnaces are coming to notice is the melting of non-ferrous alloys. For this purpose the resistance furnace will probably be most favored, although the arc furnace is used for copper-nickel alloys, and for copper-manganese. In handling brass, resistance furnaces have shown a decided superiority over both crucible and reverberatory furnaces. There is considerable saving in loss by spilling, etc., and by the elimination of crucible costs. The great factor, however in favor of electric brass-melting furnaces is their saving in volatilization losses—a saving amounting to at least 4 per cent on the reverberatory type, and to 2 per cent on the crucible type. There can be no doubt of the possibilities of the electric furnace in this branch of non-ferrous work—particularly when we consider that non-ferrous alloys possessing previously unsuspected properties have been discovered of recent years. These are particularly applicable to use in aircraft design, and their manufacture on a large scale should undoubtedly open a wide field for the use of electric heating methods.

REFRACTORIES AND ABRASIVES.

The progress attending the application of electric heating in manufacturing methods has resulted in a still further application of electro-thermic methods. The high temperatures for which electric furnaces are used have proved exceedingly severe upon the refractories of which these furnaces are built—so much so, in fact, that notwithstanding repeated experiments with improved refractory materials, we are still far from possessing ideal materials. It was early recognized that in the manufacture of those refractories required to withstand electric furnace temperatures, recourse must be made to electro-thermic methods. One of the first successful technical applications of the electric furnace to this purpose was the manufacture of fused silica-ware. Prior to 1904 fused silica was certainly used, but only in small experimental apparatus, laboriously built up from rock-crystal by the use of the blowpipe. The cost of such articles was prohibitive for all except research work. Now, however, articles of large size and of intricate shape can be made—such articles are not only refractory, but are also acid-resisting. Silica ware is of inestimable value in the chemical industry, not only for laboratory work, but for the manufacture and construction of plant required either to resist acids and acid fumes, or to stand high temperatures or rapid temperature fluctuations. Fused silica possesses a high electrical re-

*Part I appeared in this SUPPLEMENT for Aug. 30, 1919, No. 2278.

sistance, which does not decrease too rapidly with increasing temperature.

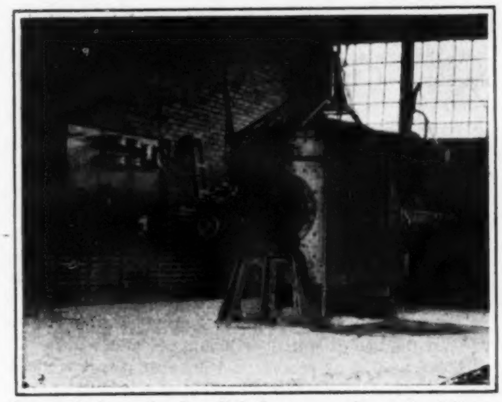
A second class of refractories, those in which the predominating element is alumina rather than silica, as is the case with silica, ganister and fireclay refractories, is even now of considerable importance to the electro-metallurgist and promises to play an even greater part in the future. Chief of these are alundum, alusil, and bauxite.

Alundum is made by fusing the naturally obtained mineral bauxite in the electric furnace. The bauxite (preferably free from iron and other impurities) is charged into a furnace of the simplest type, and the electrodes form a "smothered arc" in the material. As the mineral fuses, forming an almost pure oxide of alumina, the electrodes are raised progressively until the furnace is quite filled by a solid block of material. This is removed, crushed and bonded into refractory material suitable for use in electric furnace cores and in all cases where its extremely high thermal conductivity renders it economical, as in muffles, combustion tubes, and for high temperature electric furnace work generally. Where heat transmission is required alundum promises to be a material of the greatest value; on the other hand, this quality of high thermal conductivity renders its application to general furnace work somewhat uncertain. For instance, although alundum has been proposed as a material for the roof of electric steel furnaces, experiments have not demonstrated any great superiority over the silica brick now used. Although alundum bricks appear to be more refractory, they suffer from surface disintegration due to the action of lime and magnesia volatilized by the arc from the surface of the highly basic slags employed. The use of alundum is not confined to refractories, however; it is now finding an extensive application as an abrasive—more particularly in connection with the grading of "high-speed" steels.

Mention of abrasives produced in the electric furnace brings us to carborundum and its amorphous oxidized modification siloxicon. The former has been made for many years in electric furnaces of the simplest type and as an abrasive commands a ready sale. Its remarkable abrasive properties are too well known to be here detailed; but its sphere of application seems to be greater than it has hitherto been, for not only is carborundum a magnificent abrasive, but it possesses extremely useful refractory properties which should render it of great use in electric furnace work. Notably is this so in connection with the large resistance furnaces now under construction for annealing and heat treatment purposes. The coefficient of thermal expansion is small, much less than that of silica. On the other hand the thermal conductivity is comparatively very high, and this would seem to limit its use in general furnace work unless backed by a substantial layer of heat insulating material. For a similar reason the application of carborundum to electric furnace work is somewhat restricted, as its electrical conductiviey is good at high temperatures. As regards electric steel furnaces, experiments by Fitzgerald & Bennie have shown that no such deleterious action as is the case between lime vapor and alundum is to be feared with carborundum.

There is undoubtedly a vast scope for the production of electrically shrunk or fused basic materials, such as dolomite and magnesite. Magnesia, even when thoroughly dead burnt, cracks and spalls at high temperatures. This is due to an increase in density from about 3.2 at ordinary temperatures to about 3.6 at a white heat, with a corresponding shrinkage. If this shrinkage be produced artificially by previously heating the material to softness in the electric furnace, a substance is formed which exhibits profound differences in properties from ordinarily calcined magnesia. It is almost impervious to moist air and carbon dioxide, whereas magnesite is liable to absorb these, necessitating the utmost care in transit. The electrical calcination of magnesite yields an exceedingly valuable material; it is obvious, though, that the process is costly. Calcination by the arc furnace, though admirable, would seem to be out of the question on account of expense, but suitable resistance furnaces have been designed. Besides magnesite, lime and dolomite shrunk electrically exhibit similar properties. Their future application on a large industrial scale may confidently be predicted.

A new refractory material, perhaps the most satisfactory of all, is a product of the electric furnace. This is shrunk zirconia. Its properties are now recognized as pre-eminently suitable for use even under the most stringent conditions. The melting point of pure zirconia is extremely high (about 3,000°C.) and that of the impure mineral containing about 85 per cent ZrO_2 is not much inferior. The thermal conductivity is small (about one-half that of firebrick) and the coefficient of expansion so small that white hot crucibles may be dropped into ice-cold water without any sign of cracking. Tungsten alloys have been melted in zirconia crucibles and the boiling point of

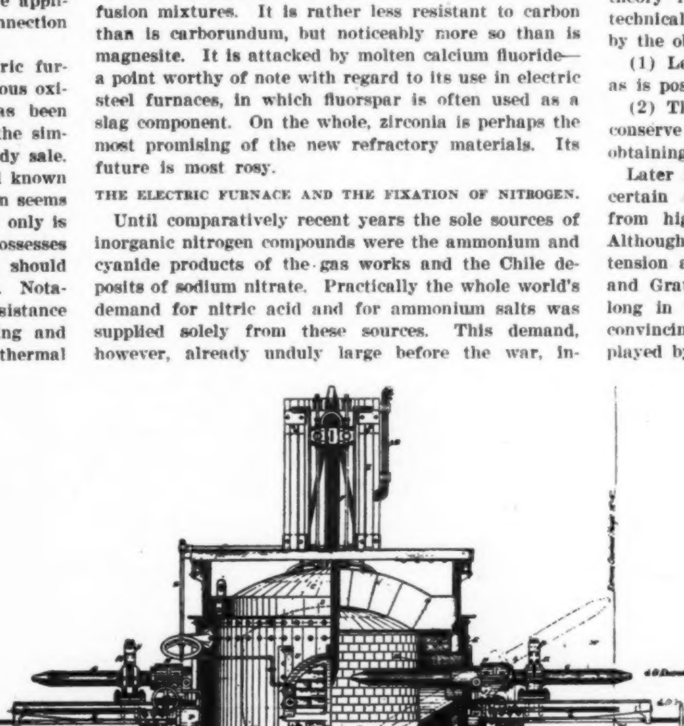


General view of a Swedish furnace. Over 13 of these small units are in use in the United States of America

iron has been determined with success. As regards chemical corrosion at high temperatures, zirconia successfully withstands the action of acids and alkali fusion mixtures. It is rather less resistant to carbon than is carborundum, but noticeably more so than is magnesite. It is attacked by molten calcium fluoride—a point worthy of note with regard to its use in electric steel furnaces, in which fluorspar is often used as a slag component. On the whole, zirconia is perhaps the most promising of the new refractory materials. Its future is most rosy.

THE ELECTRIC FURNACE AND THE FIXATION OF NITROGEN.

Until comparatively recent years the sole sources of inorganic nitrogen compounds were the ammonium and cyanide products of the gas works and the Chile deposits of sodium nitrate. Practically the whole world's demand for nitric acid and for ammonium salts was supplied solely from these sources. This demand, however, already unduly large before the war, increased enormously with the demand for high explosives (which are all nitrated compounds), for dyes to replace German products, and for fertilizers; so that methods of "fixing" atmospheric nitrogen received an enormous impetus. These methods offer a most promising future for the high temperature electric furnace.



Design of the Swedish furnace. Note the arrangement of the 3 electrodes. This furnace also successful in melting non-ferrous alloys such as brass.

The methods now in use may be classified as follows:

(1) The oxidation of atmospheric nitrogen to nitric or nitrous acid (or their salts) by the electric arc.

(2) The conversion of atmospheric nitrogen into compounds rich in nitrogen or readily yielding ammonia. These methods are in chief electrical.

(3) The combination of atmospheric nitrogen and of hydrogen to form ammonia with or without subsequent oxidation to nitric acid. Electricity plays but a small part in these methods; the reactions are usually of a catalytic nature.

The oxidation of atmospheric nitrogen presents an interesting series of phenomena, many of which are still under discussion. In the air itself we possess the raw materials for the reaction; but the conditions of thermal equilibrium between the constituents and the products is by no means simple. Long ago Cavendish discovered that air to repeated sparking diminished in volume when confined over caustic potash, and Priestly also demonstrated the converse. But the equilibrium conditions are not simple, and the evidence, notwithstanding extensive research, is not conclusive. Briefly the facts are these. The reaction

$$N_2 + O_2 \rightleftarrows 2NO$$

is reversible. By the law of mass action, the equilibrium constant (K) for any given temperature T is given by the equation:

2 is an exponent; NO, N and O are subscripts $K = \frac{C^2_{NO}}{C_N \times C_O}$ where C_N etc., represent the concentration of nitrogen, etc. At varying temperature we have $\frac{d \log K}{dT} = \frac{-A}{RT^2}$ where A is the heat of the reaction.

A has been found to equal —43.200 calories.

On integrating between T and T_1 absolute, we have the relation between the respective constants K and K_1 as follows:

$$\log \frac{K}{K_1} = \frac{A\,(T_1 - T)}{R\,T\,T_1} \text{ or } \log_{10} \frac{K}{K_1} = \frac{A\,(T_1 - T)}{2{\cdot}3\,R.\,T.\,T_1}$$

Investigations by Nernst, Jellinek and Finckh have demonstrated that concentrations in accordance with the above theoretical considerations are obtained in practice. This was thought to establish the truth of the thermal explanation. In accordance with this theory it would seem that the best results in the technical production of nitric acid would be obtained by the observance of the following conditions:

(1) Let the air be heated to as high a temperature as is possible.

(2) That the air thus heated be rapidly chilled to conserve unchanged the high concentration of NO obtaining at these high temperatures.

Later investigation has shown, however, that under certain conditions electrical phenomena as distinct from high temperature phenomena come into play. Although Nüranen and Leblanc by the use of high tension alternating arcs between refractory filaments, and Grau and Russ with vertical arcs about 7 cms. long in water-cooled silica tubes, put forward most convincing evidence as to the purely thermal part played by the electric arc in the reaction, Haber and Koenig have formulated a theory that the *primary* action is electric, as in the "silent discharge." For extremely hot arcs, as are usual in technical work, they admit that this electrical action is masked by the purely thermal one; but they maintain that by the use of low temperature arcs under diminished pressure, more efficient results will be obtained. Thus, although the present method of using high temperature arcs with rapid chilling of the products is exceedingly inefficient, the technical difficulties in the way of producing low temperature arcs such as Koenig and Haber recommend seem too great to encourage further progress in this direction.

The actual technical methods employed vary more in detail than in principle—the chief points of note being in the method of maintaining the arc and of chilling the products. The Birkeland-Eyde process uses an alternating current arc spread by an electromagnetic field into a thin disc of flame in diameter approaching two to three yards, and in thickness from two to four inches. The air current passes radially through the arc, and is then rapidly chilled to 900°C. The concentration of NO reaches a maximum of 1½ per cent. The air current is used regeneratively to heat incoming air, and is then led to the oxidizing and absorbing chambers. The Pauling process is similar; the deflection of the arc, however, is produced by the air current itself.

The Schönherr furnace differs from the foregoing in the fact that the arc is maintained at a great length (over 20 feet) inside an iron tube. The air is passed into the arc tangentially, giving it a rotary motion. Notwithstanding the fact that the air is in intimate contact with the arc for a much longer time than is the case with the above types of furnace, the yield of nitric oxide is greater (2 to 2½ per cent). This is

(*Continued on page* 191)

Alcohol Motor Fuel*

Summary of the Report of the Long Interdepartmental Committee of Great Britain

In October, 1918, Mr. Walter Long appointed an Inter-Departmental Committee to consider and report upon: (1) The various available sources of supply of alcohol, the methods of manufacture, and the cost of the product; (2) the suitability of alcohol, either alone or in admixture with solid, liquid or gaseous combustible substances, for use in internal combustion engines, and the modifications of the existing types of such engines which may be necessary to the attainment of efficiency; (3) the question of denaturing the alcohol, and the alterations to be made in the present excise arrangements.

This Committee consisted of:—Sir Boverton Redwood, Bart., chairman (since deceased), nominated by the Petroleum Executive; Major Aston McNeill Cooper-Key, C.B., nominated by the Home Secretary; Mr. Arnold Philip, Admiralty Chemist, nominated by the Admiralty; Mr. H. F. Carlill, Industrial Power and Transport Department, nominated by the Board of Trade; Professor Charles Crowther, nominated by the Board of Agriculture and Fisheries; Dr. J. H. Hinchcliff, Department of Agriculture and Technical Instruction, Ireland, nominated by the Irish-office; Colonel Sir Frederic L. Nathan, K.B.E., nominated by the Ministry of Munitions; Mr. Ralph Walter, nominated by the Ministry of Reconstruction; Sir H. Frank Heath, K.C.B., nominated by the Scientific and Industrial Research Department; Mr. Horace Wyatt, nominated by the Imperial Motor Transport Council; Sir Frederick W. Black, K.C.B.; Professor Harold B. Dixon, C.B.E., F.R.S.; Brig.-General Sir H. Capel L. Holden, K.C.B., F.R.S.; Dr. W. R. Ormandy, Mr. E. S. Shrapnell-Smith, C.B.E., Secretary, nominated by the Petroleum Executive; and Sir James Johnston Dobbie, F.R.S., nominated by the Chancellor of the Exchequer.

The report of this committee was published by his Majesty's Stationery-office on Monday evening. It runs as follows:

1. The cessation of hostilities shortly after our appointment made it desirable that we should so order the course of our proceedings as to enable us to carry the work as rapidly as might be to the point at which it would become possible to present a progress report covering generally the terms of reference. That point has now been reached, and we accordingly record our conclusions and recommendations, the adoption of which we consider to be necessary if alcohol and mixtures of alcohol with ether or with hydrocarbons, are to be brought into use for power and traction purposes as fuels alternative to petrol.

COURSE OF PROCEEDINGS.

2. We decided, for the reasons stated above, to divide the work entrusted to us between two sections, each to report to the Committee on the specified matters remitted to it. One of these sections studied the subject of "production," while the other dealt with that of "utilization."

Colonel Sir Frederic L. Nathan was Chairman of the Production Section, which was asked to report on the following matters: (*a*) Waste lyes from sulphite wood-pulp factories; (*b*) wood, including sawdust and other wood-waste; (*c*) peat; (*d*) bracken and other vegetation; (*e*) the mahua and other trees; (*f*) potatoes, maize, beet, molasses and other alimentary substances; (*g*) seaweeds; (*h*) synthesis; (*i*) ferments; (*j*) denaturants; (*k*) residuals.

Brig.-General Sir H. Capel L. Holden was Chairman of the Utilization Section, which was asked to report on any necessary action under the following sub-headings: (*a*) Admixture of alcohol with other fuels in order to permit efficient use in existing internal combustion engines; (*b*) devices and fittings, such as special primers and carburetters; (*c*) adaptation of existing engines by structural alteration; (*d*) determination of rate of propagation of flame in alcohol and alcohol mixtures, as compared with petrol; (*e*) comparative bench tests; (*f*) designs for and tests of "all alcohol" engines; (*g*) determination of effect, if any, of the products of combustion of alcohol upon engine parts; (*h*) initiation and supervision of the commercial scale, experimental use of alcohol under service conditions on the highway; (*i*) formulation of schemes for the marketing and distribution of alcohol and alcohol mixtures; (*j*) propaganda directed to educate potential consumers, and to ensure the creation of correlated and complementary interest and support.

Preliminary reports from the sections have been received and discussed by us.

3. Apart from our work in sectional meetings and sub-committees, we have held six meetings of the full Committee and examined ten witnesses, including one witness each from Canada, India and South Africa. Four of the witnesses spoke from personal experience of the production, adaptation and successful utilization of alcohol motor fuel, as a substitute for petrol, for traction or other power purposes.

We have also addressed certain inquiries to: (*a*) the Munitions Board of India; (*b*) the Honorary Advisory Council for Scientific and Industrial Research, Ottawa; (*c*) the Advisory Council for Science and Industry, Melbourne; (*d*) the South African Scientific and Technical Committee, Pretoria.

4. We have studied the report and recommendations of the Department Committee on "Industrial Alcohol" appointed by the Chancellor of the Exchequer in the year 1904, and we direct attention to the unanimous opinion expressed by that committee in paragraph 30 of the report presented to both Houses of Parliament in February, 1905, as follows: "Any question, therefore, of the use of spirit for motor vehicles will be one of price, and as at present the price of petrol is about half the price of methylated spirit, we think that close investigation of the matter may be delayed until such time as there may be an approximation between the prices of petrol and spirit sufficient to create a practical alternative of choice between the two."

It is clear to us that conditions fulfilling the anticipations of the Departmental Committee of 1904 are in sight.

5. We have received reports to the effect that some sections of the community believe that the words "industrial alcohol" refer to an inferior spirit for drinking purposes. We recommend, therefore, that all alcohol for power or traction purposes should be described as "power alcohol," and we invite all interested traders to adopt that course, subject to the later detailed provisions which we suggest in paragraph 13 of our report. This description has already been adopted in Australia.

6. To the enormous growth of road motoring during recent years, especially in the United States of America, there will now be added the requirements of high-grade petrol for aeroplanes and airships, to which no limits can be assigned.[1] We have also had evidence that the sale price of petrol to the public in America rose 200 per cent between 1914 and 1918. While it is impossible for us to forecast the development of total petrol consumption for all countries and all purposes, facts are not wanting to indicate the likelihood in the not distant future of so great a pressure of demand as to cause at any rate a very high level of prices, and we are satisfied that close investigation should now proceed with the object of providing alternative supplies of motor fuels derived from new or supplementary raw materials.

We are satisfied that the time has come for Government action, which should pay due heed to both current and prospective prices for petrol, or other petroleum products, benzol and alcohol motor fuel or its admixtures.

RESEARCH AND EXPERIMENTS.

7. Professor H. B. Dixon has undertaken at our request the direction in an honorary capacity of a scheme of experimental research in the Chemical Laboratories of Manchester University. The completion of this research, the object of which is to provide accurate data concerning the behavior of alcohol, alcohol-benzol, alcohol-ether, and other alcohol mixture vapors on their combustion with different volumes of air and with varying percentages of water and denaturants, is estimated to occupy a further period of at least six months.

The necessary expenditure on apparatus, staff and sundries for this work was generously met by the Royal Automobile Club and the Commercial Motor Users' Association jointly.

8. We carried through, with the concurrence of Professor Sir John Cadman, Director of H.M. Petroleum Executive, the necessary arrangements with the Lords Commissioners of H.M. Treasury, the Board of Customs and Excise, and the board of directors of the London General Omnibus Company, Limited, for a practical trial over a period of about twenty-six weeks of alcohol-benzol and alcohol-benzol-petrol mixtures in one complete fleet of motor omnibuses. The company has undertaken to make various incidental bench and other tests for our information, and to place its full records, including comparative results with other fuels, at the disposal of the State. The difference in price between the actual cost under war conditions of the alcohol used for this experiment and the price which the company would have paid for equivalent petrol, was borne by the funds of H.M. Petroleum Executive.

The directors of the London General Omnibus Company, Limited, in acceding to our request to afford facilities for a large-scale trial in London under daily service conditions, and under our supervision, have afforded us an unequalled opportunity of acquiring for public use records of great importance in their bearing upon future transport developments, and we desire to take this opportunity of recording our appreciation of their public-spirited action.

This commercial scale trial is now proceeding.

FUTURE SYNTHETIC PRODUCTION.

9. We have received exhaustive technical evidence from representatives of the Ministry of Munitions concerning the investigations made by them during the war in respect of the extraction of ethylene from coal and coke-oven gases, and concerning quantitative results so obtained. Lord Moulton, in his capacity as Director-General of the Explosives Department of the Ministry, sat with us at one of our meetings when this subject was specially considered in relation to future output, the synthetic conversion of the ethylene in ethyl alcohol, and the estimated costs of the processes involved.

The testimony of witnesses and records of work done indicate that there is thus available in Great Britain a large potential source of power alcohol, but further investigations are necessary in this connection, particularly as regards the conversion of the ethylene into alcohol before definite figures as to quantities and price can be given.

VEGETABLE SOURCES.

10. The outstanding and fundamental attraction of alcohol motor fuel as a substitute for any fuel necessarily derived from coal or oil deposits lies in the fact that, on account of its chief sources being found in the vegetable world, supplies of raw material for its manufacture are being continuously renewed and are susceptible of great expansion without encroachment upon food supplies.

We are of opinion that steps should be taken to ensure increased production of power alcohol by the extended use of the vegetable matters from which it may be obtained. Important materials of this nature are: (1) Sugar-containing products, such as molasses, mahua flowers, sugar beet and mangolds; (2) starch or inulin-containing products, such as maize and other cereals, potatoes and artichokes; and (3) cellulose-containing products, such as peat, sulphite wood-pulp lyes and wood.

We have been unable to obtain comprehensive estimates of the world's production of molasses, although we have been furnished with statistics concerning the total quantities shipped from various countries, but there is evidence that large quantities produced in numerous sugar-growing areas are allowed to run to waste.

We have received interesting evidence from the Director of Commerce and Industries to H.E.H. the Nizam of Hyderabad (Deccan) concerning achieved production costs and yields of power alcohol from the flowers of the mahua tree (Bassia latifolia), which flourishes in the Central Provinces as well as in Hyderabad. The witness stated that the sun-dried flowers of this tree contain on the average 60 per cent by weight of fermentable sugar, that they can be collected and delivered to the factory in the zone of growth at £1 10s. per ton, and that the yield on proper fermentation and distillation is found to be about 90 gallons of alcohol—95 per cent by volume absolute—per ton. He further stated that the flowers can be pressed, packed, exported, and stored for long periods without deterioration. We also understand that cultivation of the mahua tree has not as yet been attempted, and that there may, therefore, be possibilities of increased production of flowers by cultural treatment.

*Reprinted from *The Engineer* (London).

[1] The petrol consumptions and annual increases in the United States of America alone have, for all purposes, been as under:—

Year.	Total consumption. Imp. gals.	Increase over previous year. Imp. gals.
1914	1,200,000,000	—
1915	1,400,000,000	200,000,000
1916	1,680,000,000	280,000,000
1917	2,320,000,000	640,000,000
1918	2,680,000,000	360,000,000

The reduction in rate of increase during the year 1918 was on account of civilian economies to make provision for war requirements. The 1919 increment promises to exceed that for 1917.

The large-scale cultivation of maize and other cereals as raw material for the manufacture of power alcohol has admitted possibilities, as to the full extent of which we have been unable to complete our inquiries, but it would appear that prospective production of alcohol from these sources in the overseas Dominions and other parts of the Empire is encouraging both as regards quantities and cost.

Seeing that one ton of potatoes yields only 20 gallons of 95 per cent alcohol, while the yield from artichokes is only very slightly higher, we are of opinion that having regard even to the pre-war prices of potatoes and artichokes in the United Kingdom, power alcohol cannot be produced in this country from these sources on a commercial basis except under some system of State subvention. Similar considerations apply also to the sugar-beet and mangold crops.

No satisfactory method for the utilization of peat as an economic source of power alcohol has been brought to our notice. We are however, of opinion that in connection with researches into the use of peat for various purposes, its potential value as raw material for the manufacture of such alcohol should not be overlooked.

We are of opinion that, so far as vegetable sources of raw material for the manufacture of power alcohol are concerned, we must rely mainly, if indeed not entirely, on increased production in tropical and sub-tropical countries.

DENATURANTS AND DENATURING.

11. We have received a valuable report from the Government Chemist, Sir James J. Dobbie, upon practices usual in all countries to effect the denaturing of alcohol, so that it shall be unfit for human consumption and proof against illicit purification to render it potable. It appears to us, however, that as regards the United Kingdom new conditions would arise if the market price of petrol were to remain permanently as high as that of denatured power alcohol, or approximately as high.

The use of alcohol as a fuel for power or traction purposes in the United Kingdom has not been commercially practicable hitherto, by reason of the high price compared with that of petrol. Since the denaturing process now in use admittedly increases the cost, sometimes by as much as 6d. per gallon, the increase should be restricted as much as possible by reducing the proportion of the principal denaturant, wood-naphtha. In all cases of approved use for power or traction purposes, where the user gives bond, the proportion of wood-naphtha in the power alcohol might be substantially diminished, the difference being made up, wholly or partially, by petrol, benzol or other nauseous substance, supplemented by a small quantity of methyl violet as coloring, but, in our opinion, a further deterrent can be provided by the imposition of much heavier penalties than those now sanctioned by law for evasion of the spirits duty in any case of illicit purification of power alcohol to render it potable.

The lowest attainable cost for denaturing power alcohol should be officially recognized as an important consideration, in addition to the necessity of securing a non-potable spirit and protecting the revenue against fraudulent practices.

We recommend that every effort should be made by research and practical trial to provide a denaturant or alternative denaturants—*e. g.*, formaldehyde, pyridine and tobacco oil—the employment of which will be effective in the smallest possible quantities and at the lowest possible cost per gallon of power alcohol.

We are of opinion that when denaturing operations are carried out at any transport depot or yard, the existing regulations of the Board of Customs and Excise should be relaxed to permit the necessary volumetric mixings to be made in any suitable tank or other storage vessel notwithstanding the fact that such vessel may still contain power alcohol previously denatured, provided that no re-filling supplies for vehicles are drawn during the operations nor until after the new mixing is completed to the satisfaction of any officer of the Board in attendance.

FACILITIES FOR IMPORTATION AND DISTRIBUTION.

12. Our attention has been directed to the possibility at no distant date of the importation from Canada, India and South Africa into this country of power alcohol shipped in tank steamers. This proposal is obviously in part dependent upon the provision of adequate storage facilities at the ports of arrival, and it is our opinion that no impediment should be placed in the way of manufacturers or importers who seek to promote such new developments of fuel supply. If power alcohol is denatured to an approved specification before landing in this country, it appears to us to be superfluous to impose the usual bonded warehouse rules and regulations upon those who store and handle it after landing, although we are agreed that special rules will have to be observed.

Other witnesses have pointed out the advantages of the transportation of power alcohol by rail or road in tank wagons instead of drums, barrels or other small containers. This proposal is one of more immediate interest. The London motor omnibus trial has already produced an application for permission to convey power alcohol by road in tank wagons, although the London General Omnibus Company, Limited, at the suggestion of the Board of Customs and Excise, did not press the request. We are of opinion that the use of rail or road tank wagons of the usual construction, or of any other type approved by the Board of Customs and Excise, should be allowed for the purpose in question, under seal if the alcohol be undenatured, and that the extension of such methods of conveyance should be facilitated by all concerned.

We recommend that, having regard to the exemption of home-produced benzol and shale motor spirit from the motor-spirit tax—excise—power alcohol when produced in the United Kingdom be correspondingly exempted, and that having regard to the scope for earlier large production in the Empire overseas, importation of power alcohol be permitted free of duty.

13. All sales and deliveries of power alcohol should be made on the basis of a certified percentage by volume of absolute ethyl alcohol, with a minimum of 90 per cent at a temperature of 62 deg. Fah.

We are of the opinion that in denatured alcohol, or in admixtures of alcohol, benzol, ether, petrol or the like, sold as power alcohol, the ratio of water to alcohol after admixture should not exceed one part by volume of water to nine parts by volume of alcohol measured at ordinary temperatures.

We further consider that when benzol, ether, petrol or the like are mixed with alcohol in quantities in excess of those which may be legally required as partial denaturants, the nature and amounts per cent by volume of such components should be plainly stated on the containers of such mixtures and on the contracts salesnotes and invoices dealing therewith.

FUTURE STATE ACTION TO DEVELOP PRODUCTION AND FOSTER UTILIZATION.

14. We have, in a preceding paragraph—No. 10—referred to the basic difference between alcohol on the one hand and benzol, petrol or other petroleum products on the other—a difference which has not as yet been properly appreciated—*i. e.*, the fact that the chief raw materials for the production of the former can be renewed and are susceptible of great expansion, while those from which the latter are derived are limited to deposits, definite in extent, that cannot be renewed. Furthermore, as power alcohol is miscible with water in all proportions, its use affords greater safety from fire than does the employment of benzol, petrol or other petroleum products. We consider that these two factors should be regarded as sufficient grounds in themselves to justify State action in fostering the production and utilization of alcohol for power purposes.

The work of the sections, so far as it has been carried, has been sufficient to show the complex and far-reaching character of the problem, and has convinced us that it can only be handled adequately by concerted Government action.

We think that the development of the alcohol industry cannot be left entirely to the chances of private enterprise, individual research and the ordinary play of economic forces. No doubt in the long run, after a tedious process of trial and error, alcohol would find its proper place as a power fuel, but only with the maximum of friction, great fluctuations in price and serious waste of time, money and energy. The situation needs to be watched continuously, and measures taken from time to time to ensure a smooth and rapid adjustment of supply to demand.

15. We are of opinion that the question of State action to educate the public concerning the merits of power alcohol and mixtures of that fuel, by demonstrating through the agency of series of lectures and exhibitions or other appropriate means, the manner in which these alternative fuels can be best applied as sources of power in motor vehicle and stationary engines, should be seriously considered.

16. It is amply evident that any further investigations concerning the production of power alcohol should include an examination into the necessity for revision of the statutory regulation that the specific gravity of distillers' wort before fermentation must be ascertained by means of the saccharometer.

It is equally essential that the necessity to allow fermentation and distillation to proceed simultaneously in the same building, and to allow continuous distillation, should receive early consideration.

GENERAL RECOMMENDATIONS.

17. We are of opinion that the time has come for action by the Government to ensure close investigation of the questions of production and utilization in all their branches of alcohol for power and traction purposes.

In the British Empire there are vast existing and prospective sources of alcohol in the vegetable world, although in the United Kingdom itself production from these sources is now and is likely to remain small, but synthetic production in this country in considerable quantities, especially from coal and coke-oven gases, is promising.

As the price of alcohol for power and traction purposes, to which we propose the name of "power alcohol" should be given, must be such as to enable it to compete with petrol, it is essential that all restrictions concerning its manufacture, storage, transport and distribution should be removed so far as possible, consistent with safeguarding the revenue and preventing improper use, and that cheap denaturing should be facilitated.

We recommend that an organization should be established by the Government to initiate and supervise experimental and practical development work, at home and overseas, on the production and utilization of power alcohol, and to report from time to time for public information on all scientific, technical and economic problems connected therewith. This organization should be permanent, have at its disposal the funds necessary for its investigations, be in close relation with the various Governments of the Empire, and be so constituted as to be able to deal with alcohol in conjunction with other fuels which are or may become available as a source of power.

18. Finally, we are of opinion that steps to facilitate the production and utilization of power alcohol in the United Kingdom can in no circumstances be taken, nor arrangements for such development carried into effect, unless provisions and alterations of the kind we recommend in our report are made in advance of the time when an acute recurrence of high prices for motor fuels may otherwise call for action too late for it to be effective.

A Theory of the Flow of Water Over a Canal Weir*

By L. L. Wickham

The formula for calculation as to the discharge over a simple weir in a still-water reservoir, seems to give fairly satisfactory results, but the formula for the discharge over a canal weir does not seem to yield results that are satisfactory. The formula for canal weirs is arrived at by taking into consideration the velocity of approach, and by adding this to the formula for discharge over a simple weir from a still-water reservoir. If the velocity of approach was the only difference between the two cases, the existing formula would probably be the best procurable, but there seems to be other differences which may possibly account for the formula proving unsatisfactory.

The water flows from the reservoir without any swirls appearing on the surface, and the flow may be said to be non-sinuous motion not only when the water passes over the weir, but when it flows towards the weir. The water flows in a canal in turbulent motion and swirls are seen on the surface, consequently the motion of the water in the canal has to change from turbulent to nonsinuous motion when passing over the weir. There is also a change of the relative velocity of the upper and lower layers of the water. When the water flows in a canal the velocity of the upper layers is greater than that of the lower layers. When the water flows over the weir the velocity is least on the surface and greatest at the bottom, consequently there must be considerable increase in the velocity of the lower layers before the water can pass over the weir. There is also a gradual decrease in the surface fall of the water from some distance above the weir, and just above the weir the surface is practically level. If this latter peculiarity is not allowed for, when designing the weir, the bed of the canal is scoured out and the surface is lowered, which seriously affects irrigation, when the surface fall is about 1 foot per mile or over. This lowering of the surface level ceases when the natural conditions of flow over a weir have been obtained.

As the difference between the flow of water over a reservoir weir and a canal weir is not a mere difference of velocity of approach, it seems advisable to discover some rational theory that accounts for the difference, in order that it may be possible to construct not only a new formula for discharge, but also for the height to

(*Continued on page 187*)

*Communication to *Engineering* (London).

A Spherometer of Precision*

An Attempt to Free the British Optician from the German Instrument Maker

By J. Guild, A. R. C. S., D. I. C., F. R. A. S.

The type of spherometer herein described was designed with a view to obtaining greater accuracy in the determination of the exact point of contact of the micrometer leg with the surface of the lens or flat under examination than is usually obtained with spherometers of existing patterns. The essential features of the instrument are indicated in Fig. 1.

The lens or flat, L, under test rests upon three spheres, of which only two are shown at AA. These spheres are mounted upon an adapter,[2] so that by using different adapters the instrument is suitable for surfaces of different sizes. The micrometer S is screwed up from below: it terminates in a small spherical surface B of one to two millimeters diameter, of which the apex is exactly concentric with the screw.

When B is in contact with the surface of L a system of Newton's rings will be visible if suitable illumination and observing apparatus are provided. For this purpose there is mounted above the spherometer a microscope M, with an ordinary vertical illuminator V

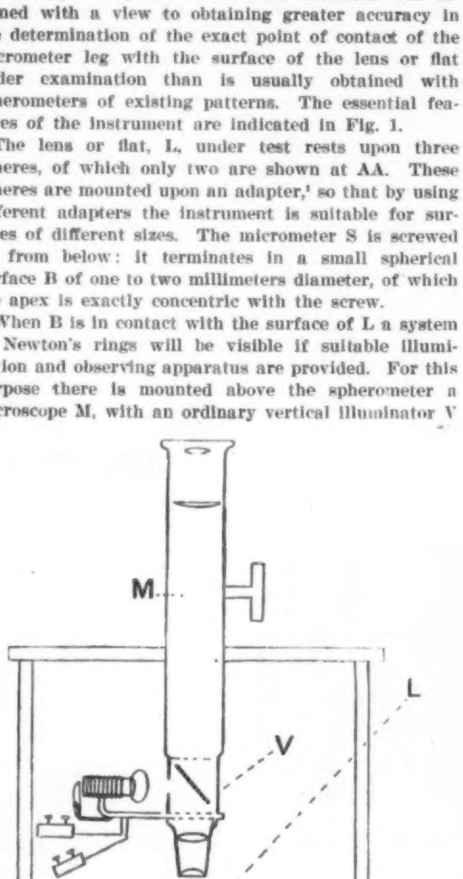


Fig. 1. General arrangement.

fitted above the objective. Illumination is supplied by a small 4-volt lamp on a bracket fitted between the objective and vertical illuminator. A piece of Wratten No. 25 gelatine filter (red) is mounted behind the aperture of the illuminator and renders the light sufficiently monochromatic for a considerable number of interference fringes to be seen surrounding the point of contact. Filters of other colors were tried and proved equally satisfactory, though the author prefers the red field for comfort in working.

The method of using the instrument can now be briefly explained. Suppose that the small sphere B is gradually approaching the surface of L. When it comes within a short distance of it the fringes become visible on suitably focussing the microscope. As the separation diminishes the fringes expand outwards, a fresh one appearing at the center for each half wave length that the screw advances; but at the moment at which contact is made and the lens L begins to lift the expansion of the fringes ceases abruptly. This point can be determined with certainty to less than one five-thousandth of a millimeter. It is better, however, to use as the criterion of contact not the point at which motion of the ring system ceases but some easily recognized configuration just before this stage is reached. A convenient configuration is that in which the central black spot approximately trisects the diameter of the

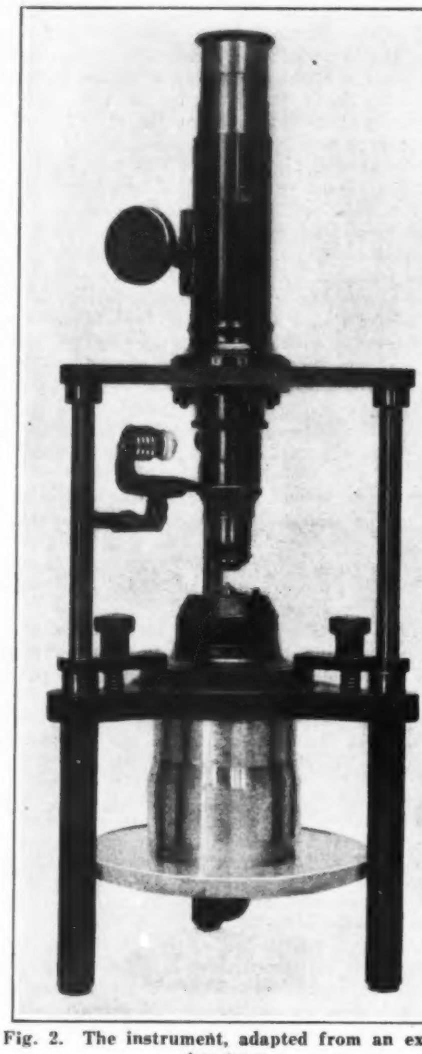


Fig. 2. The instrument, adapted from an existing type.

first black ring. This has the advantage that the appearance continues to alter for a little beyond the required setting, which is more satisfactory in practice than when the criterion adopted is one-sided. But the most important advantage in the use of this setting is in the elimination of a source of error which is inherent in any spherometer in which, when the criterion of "contact" is reached, the weight of the lens is borne either wholly or in part by the central point. In working with this instrument it is found that when the lift-point is reached and the fringes cease to expand the central spot is spread out to an extent depending on the weight of the lens. Thus with a light eye-piece lens its diameter may not exceed a third of that of the first ring; whereas with a fairly heavy lens or flat it may at most fill the first ring. This spreading out of the black spot indicates a compression partly of the small sphere B and partly of the lens surface; and the result is that the lift-point is not attained until the screw has advanced beyond the point of geometrical contact. Clearly, unless the lens and the flat on which the zero reading is made are of the same order of weight, an error will arise from this cause. Since the same flat has usually to serve whatever size of lens is being measured up, this condition cannot generally be fulfilled. As regards the magnitude of the error, the weight correction for a circular flat of two inches diameter and one-quarter inch thick (weight = 35 gm. approx.) was about four ten-thousandths of a millimeter with the smallest adapter. It is greater in the case of larger adapters, though this is partly compensated by the smaller difference in weight between the flat and the lenses tested on these. Errors of this magnitude are several times larger than the experimental error with this type of instrument. It is obvious that such errors will be of much larger magnitude in instruments in which the micrometer terminates in a point instead of a sphere, so that pointed ends should be avoided in all spherometers. They have no advantages over rounded ends, and have several disadvantages in addition to the one discussed here.

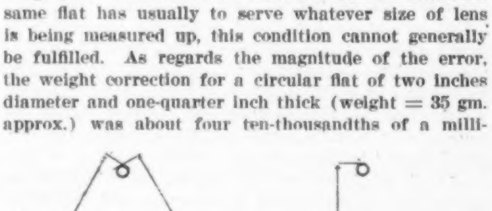


Fig. 4. Measuring the radius of the supporting circle.

With the author's instrument not only can the weight error be investigated quantitatively, but in ordinary use it can be entirely overcome by using the criterion of trisection of the first ring by the central spot; for at this stage in the approach compression has not yet commenced, and an exactly similar degree of "contact" is obtained whatever the weight of the lens or flat.

Fig. 2 is a photograph of an actual instrument adapted from an existing pattern of spherometer. The lower portion is simply the lower portion of this instrument with the addition of a milled disc of larger

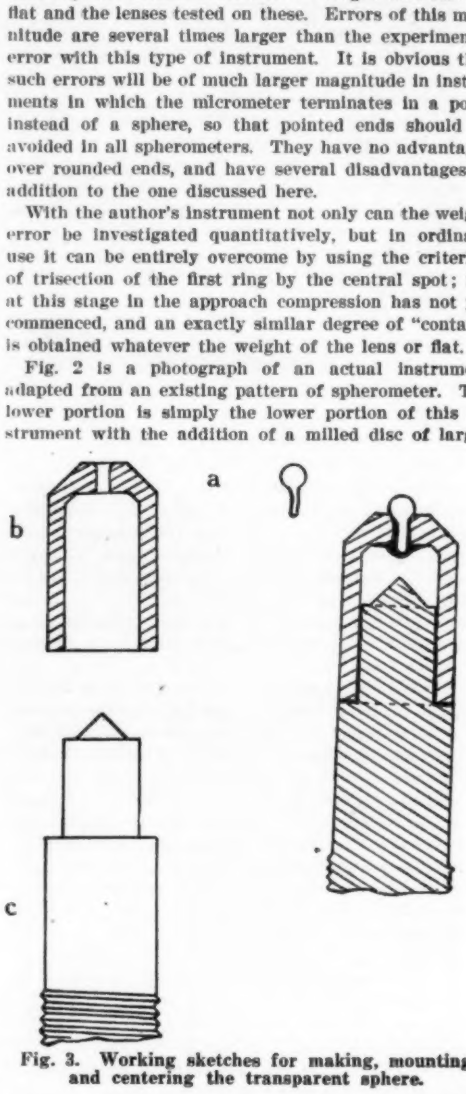


Fig. 3. Working sketches for making, mounting and centering the transparent sphere.

diameter than the drum to increase the accuracy of setting, and with the central steel point replaced by a small sphere. This sphere is of glass, because it was easier to make with the facilities at hand; but a quartz sphere would be preferable on account of its lesser liability to accidental scratches.[3] The superstructure of the original instrument is replaced by that shown in the photograph, which carries the microscope and vertical illuminator. A one-inch objective and a × 12 eye-piece, with a tube length of 12 to 14 cm., give a suitable magnification. The objective should have as long a working distance as possible to allow of its use with fairly thick lenses. The vertical illuminator is of the ordinary type, having a single cover glass reflector (unsilvered).

It is best to use three dry cells of moderate size for the lamp, as the small flash-lamp batteries are always giving out at the least convenient times.

With this instrument settings can be repeated to about one ten-thousandth of a millimeter with very little practice. This is of course far in excess of the accuracy of which the screw and other mechanical parts are capable; so that the measurements are by no means reliable to a degree corresponding to the sensitivity of setting. Experience with the actual instrument shows, however, that the interference ring method of detecting contact is sufficiently sensitive to obtain the utmost accuracy from an instrument of the highest mechanical perfection. Further, the accuracy is the same whatever size or type of lens is being measured—a most important point in an instrument which has to be employed for small eye-piece lenses, etc. With many, if not most of the existing types of

*A paper read before the Optical Society and published in its *Transactions*.

[2]The type of adapter in which the surface rests on a ring instead of three spheres would do equally well.

[3]A steel sphere was tried in the first instance; but the fringes given by this were not nearly so distinct as with a transparent material. Further, on account of the comparative roughness of the surface, the fringes were so irregular that the trisection method of setting could not be employed.

spherometer, the accuracy with small diameter lenses is much less than with those for which the larger adapters can be used, especially if the curves are steep.

There is also a great saving of time with this instrument, one setting requiring only a few seconds.

It is of interest to investigate the possible precision of an instrument of this design. A change of a complete fringe corresponds to half a wave length of light in screw travel, *i. e.* to one four-thousandth of a millimeter approximately. Since settings can be made without difficulty to a fifth of a fringe, if not less, an accuracy of a twenty-thousandth (1/20,000) of a millimeter is attainable with ease as far as the method of setting is concerned. This, unfortunately, is far in excess of the accuracy with which micrometer screws can be manufactured or tested at present.

The best method of making, mounting and centering the transparent sphere on the end of the micrometer screw is, of course, a matter for the instrument maker; but the method employed by the author in adapting his own instrument may be of interest to anyone who might desire to adapt an existing spherometer of suitable type for use by the interference method.

The end of the screw was turned down to a depth of about 0.5 mm. for a length of about 5 mm., Fig. 3 c, and a steel sleeve, Fig. 3 b, of 1 cm. length was made to fit firmly over the narrow portion. In the closed end of this sleeve a slightly countersunk hole of about 1 mm. diameter was bored. This was done while the sleeve was in position on the end of the micrometer (which was fitted in a lathe) so that the hole should be exactly concentric with the screw.

The glass sphere was made by drawing out glass rod to about 0.5 mm. diameter or less, and fusing the end in the blowpipe flame until the sphere which is thus formed had grown to the required size. A number of such spheres can be turned out in a few minutes, and it is easy to find one that is reasonably spherical, of the right size, and free from air bubbles and other defects. A sphere having been chosen, it was broken off with about an eighth of an inch of the thin rod left as a neck, Fig. 3 a.

The micrometer screw was mounted vertically in guides, one of which was close up to the sleeve, so that it could be rotated about its axis without shake. The lip of the hole was smeared with seccotine (which takes some little time to harden) and the sphere was placed in position as shown in Fig. 3 d. A strip of microscope cover glass was then supported so that it rested horizontally on the sphere and on two other supports attached to the upper guide. Thus mounted the cover glass is approximately perpendicular to the axis of the screw. A microscope with a scale in the eyepiece was mounted so as to observe the Newton's rings between the sphere and the cover glass. Any slight want of centering of the highest point of the sphere was now made evident by the movement of the rings in the field of view when the screw was rotated in the guides. This was corrected by pushing the sphere in the proper direction with a suitable implement until, on rotating the screw, no appreciable movement of the interference rings took place. The adjustment had to be repeated from time to time as the seccotine hardened, on account of uneven shrinkage. As little of the adhesive as possible should be employed. When the seccotine was perfectly hard the sleeve was removed and a mixture of beeswax and resin was melted into the upper end, filling up the small hole and completely surrounding the neck of the sphere, which was thus held in position with perfect rigidity. The sleeve was replaced on the end of the screw, and the latter returned to its place in the spherometer.

Subsequent checks of the centering adjustment have not revealed any appreciable shift due to creeping of the materials used in mounting the sphere.

The centering of the adapters is done once and for all by the makers, the adapters being such an accurate fit that they always return exactly to the same position. There are two convenient methods of measuring the radius of the circle on which the centers of the three spheres lie. The first of these is to measure, with a micrometer gage, the distances l, m and n [Fig. 4 (a)]. Subtracting the diameter of the balls from each of these gives us the three sides of the triangle at the corners of which the centers of the balls lie, and the radius of the circumcircle is calculated from these. As a check on this value the distances u, v and w [Fig. 4 (b)] are also measured. By subtracting from the mean of these the radius of a ball and also the radius of the cylindrical end of the spherometer screw (the measurement, of course, being made near the end where there is no thread) the radius of the circumcircle is again obtained. This measurement should not be made from the sides of the central sphere, as this is unlikely to be sufficiently spherical to give accurate values.

The second method of measuring the distances between the various spheres is to lay an optical flat on them and measure with a travelling microscope the distances between the centers of the Newton's ring systems formed at the contacts.

If R is the radius of the circle through the center of the three balls, and h is the displacement from its zero position of the micrometer point when making contact with a surface of radius r resting on the three balls, $r = R^2/2h + h/2 \pm a$, where a is the radius of the balls. The + sign applies to concave, and the — sign to convex surfaces.

For a ring adapter the diameter of the two significant edges of the ring can be measured on a travelling microscope.

The Effect of Finger-Heat Upon the Micrometer Gauge

By Lindley Pyle, Professor of Physics, Washington University

WIDER publicity should be given to the effect of the heat of the fingers upon the readings obtained with instruments of precision. Of course, no one keeps his fingers in contact with the bulb of a thermometer used in finding the temperature of the air. This is an extreme case. Consider another instrument. How many mechanicians are aware of the effect of finger-heat upon the readings of a micrometer gage? None, practically speaking. Figures 1 and 2 show the usual methods of gripping the instrument in the fingers. So far as accurate measurements are concerned, Fig. 2 illustrates the more desirable method assuming that the temperature of the gage differs from that of the fingers.

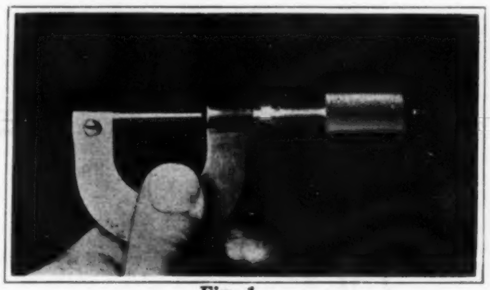


Fig. 1.

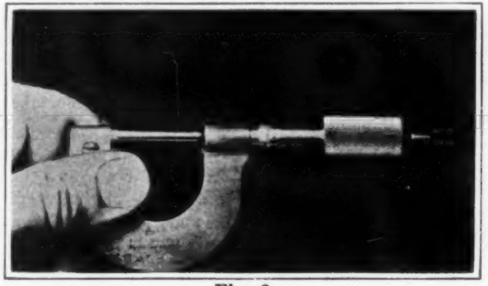


Fig. 2.

The wrong and the right way to handle a micrometer gage.

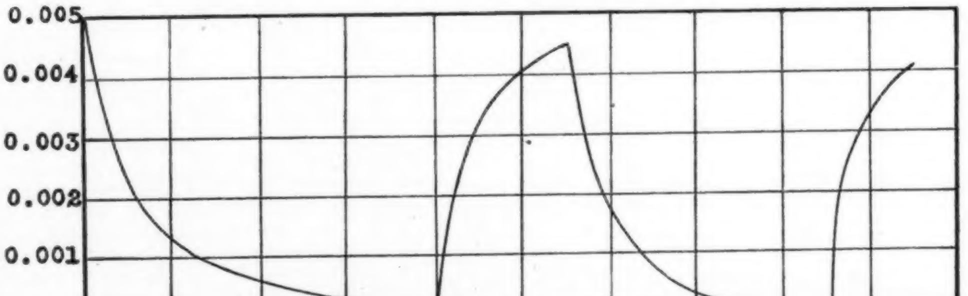


Fig. 3. Effect of finger heat upon the zero reading of a micrometer gage. The abscissas represent minutes; the handling which produced the variations is described in the text.

The curve of Fig. 3 shows the changes in the readings of a micrometer gage, dating from the moment when the gage is picked up as in Fig. 1, in a room at 73°F., and by a hand at 93°F. The gage is kept in the fingers for 4 minutes, is then exposed to the free air for 1.5 minutes, gripped again in the fingers for 3 minutes, and again exposed to the free air. The readings are the so-called *zero-readings* obtained by closing the jaws of the empty instrument. This particular gage was equipped with the ratchet device whereby the same pressure is always exerted by the closed jaws. The maximum change observed was 0.005 millimeters, the rate of change at times being as great as 0.001 mm., in 5 seconds. Of course these effects are negligible in the case of large work; on the other hand they may correspond to large percentage errors in the callipering of fine wires. No sensible effects are observed when the gage is gripped as in Fig. 2.

Of course the effects arise from expansion due to rise of temperature in that part of the instrument between the fingers placed as in Fig. 1. The expansion parallel to the axis of the micrometer screw leads to the widening of the gap between the jaws and hence to a *decrease* in the closed jaw reading. In the case studied the region warmed by the fingers approximated roughly to 4 centimeters as measured parallel to the axis of the screw. Recalling that steel expands six-millionths of a linear dimension for a rise of temperature of one degree Fahr., or 120-millionths for a rise of twenty degrees (93-73), it follows that for 40 millimeters the expansion would be 0.0048 mm. This checks with the observed change of reading in the first four minutes of the curve data of Fig. 3.

It is a thing of practical interest that, in this instrument, for each Fahrenheit degree excess of the finger temperature over room temperature the reading of the gage in the hand (as of Fig. 1) may be 0.00025 mm., less than the reading of the gage insulated from the fingers. It is recommended that the gage be held always as in Fig. 2, or else wrapped in a heat-insulating material.

Connected D. C. Motors

THERE are numerous cases in which it may be more advantageous to have two d.c. motors, connected in parallel or series, than only one motor. Where no stoppage through breakdown can be tolerated, motors must be duplicated, or where a large number of motors of one size are used in an establishment, it may be preferable to use two motors of the standard size to installing one larger one. Or two motors in stock may be combined, and so the purchasing of a new one be avoided. Small motors take less floor space and may be fittted in where space is at a premium, they weigh less, are more easily handled and dismantled and more easily standardised.

Two motors may be connected in parallel so that they together handle the full load, while the larger one alone carries the normal load.

Some of the reasons for using two motors in parallel apply equally if the two are connected in series. Other advantages are peculiar to the series connection. The control of two motors in series is simple and inexpensive, being almost equivalent to that required for one of the two motors. Two motors in series develop starting torque equal to that of two connected in parallel, but with less total current input, since the same current passes through both. In rapidly reversing drives, where the motors attain considerable speed and their inertia is a serious factor, series connection may lead to a more rapid operation.

Motors are sometimes arranged for operation either in series or in parallel. Traction service is a notable example. Up to half speeds the motors are connected in series; for higher speeds, in parallel. This is simple and economical in power.

The article describes the general conditions for operating motors in series or in parallel, shows different schemes of connecting series motors in parallel, and concludes by noting a few points concerning the control of motors connected in this way.—*Fox, Power.*

Climatic Variations Conducive to Health

A WRITER in *Modern Medicine* emphasizes the fact that the death rate is lower in climates subject to marked variations from season to season than in mild, uniform climates. In the latter persons become over-sensitive to changes and their powers of resistance are diminished. A variable climate has a stimulating effect on health.

Aviation Textiles and Chemistry*

A Review of the Increased Efficiency and Service Resulting from Combining the Two Sciences

By Adolphe Rusch, Jr.

[Reprinted by permission of the Alumni Association of the Philadelphia Textile School.]

WHEN we consider the wonderful feats performed by the airplane, which helped to bring the greatest of struggles to a victorious close, we must not forget that textiles and chemistry played an important part in bringing the airplane to its present state of utility. The wings and body, or fuselage, of every airplane used by the Allied Forces and the United States were covered with textile fabrics which were treated with chemical compounds in order to make flying possible.

REQUIREMENTS OF FABRICS.

Before taking up the chemical treatment of these fabrics, it is of interest to briefly state the requirements demanded of them, for they must be constructed with regard to special qualifications. It is necessary to combine the greatest strength with the lightest weight possible. The strength of these fabrics averages 80 pounds to the inch, and the average weight is 4½ ounces per square yard. Fabrics were constructed which aimed to improve these specifications with the result that fabrics now in use show a great deal more strength to the weight. The fabric must be so constructed that it is capable of shrinking when "dope" is applied to its surface. Dope is a term commonly applied to a solution of a cellulose ester which causes the fabric to contract. Such shrinkage is not the result of any physical or chemical change in the fiber, as in mercerization, but is brought about by the shrinkage of a film produced by the dope. The shrinkage of côlloids drying from a solution is a common phenomenon. The fabric must also have approximately the same strength in both warp and filling, and must have a high tearing resistance when doped. A great many weaves were tested but the plain weave was found to be most practical, because it produced a more coherent and uniform fabric.

When this country declared war, linen was used almost exclusively, but the demand for linen produced such a scarcity of this fabric that we had to look for some other fiber to meet the requirements. We naturally turned to cotton, but considerable experimentation was necessary in order to get the strength of linen, and the proper behavior of the fabric when doped. It was necessary to reproduce in cotton the strength which characterizes the linen fiber. Silk fabrics were also considered, as these have greater strength per unit weight than linen or cotton; but on account of the high cost of silk, these fabrics were used only on planes designed for special purposes. The cotton fabric designed in this country was accepted by the Bureau of Aircraft Production, and later by Great Britain, who was forced thereby to concede its superiority over anything produced in that country. It was constructed on a plain weave, with warp and filling practically identical, and the yarns were mercerized. These fabrics were wrapped around the wings of the plane, or formed into a bag and slipped over the wooden rods of the wing. They were then firmly sewed and fastened to the wooden structure. The fuselage was covered also. An airplane covered in this fashion is unsuitable for flying because it is readily penetrated by air and moisture, and is not uniformly taut, and has a rough surface which lowers the speed of the plane. It must therefore be doped.

USES OF DOPE.

In the early days of construction of heaver-than-aircraft, the wings were covered with unproofed cotton stretched as tightly as possible. Flying was possible only in fine weather, and it was evident that some means must be provided to make the fabric uniform under varying conditions of temperature and humidity. Rubberized fabrics and fabrics treated with glue and casein used as such or treated with potassium bichromate or formaldehyde to make these compounds insoluble, fabrics treated with linseed oil, mixtures of beeswax and paraffin, and other compounds were tried, but for various reasons abandoned. The fabric was affected by moisture, or the treatment lacked durability, or the wings were penetrated by oil splashed from the motor and were softened. A French art student, Vosin, later an aviator, recalled the use of starch paste to stretch a canvas before painting, and applied the fact to airplane wings. Starch paste is used today in experimental work. Shrinkage was found to be a desirable quality in treatment of the wings, and subsequently was obtained by the application to the fabric of solutions of collodion or guncotton. On account of the inflammability of guncotton, the use of thin sheets of cellulose acetate was recommended, and led to the use of cellulose acetate in solution. Cellulose acetate dopes are most commonly used today, particularly on planes designed for combat purposes.

A dope must, therefore, produce shrinkage, causing the wings to become drum tight, and produce a spring-like action in the air similar to a highly inflated pneumatic tire. This imparts speed and lifting qualities to the plane. It must also resist the penetration of wind and moisture and make the fabric stable under all conditions of flight. It must present a smooth surface so that wind resistance or skin friction is reduced to a minimum, and finally should be as fireproof as possible. The dope, therefore, protects the fabric. It is also customary to protect the dope by means of a dope cover consisting of clear varnish, enamels, or pigmented dopes. Experimental work indicates that the only agent which is effective in decomposing the dope film is sunlight. Clear varnish is therefore a poor dope cover, and enamel is better, but the pigmented dope is best of all because it dries rapidly, and permits of quick repair work. Dopes must be thoroughly dry before the application of varnish and enamels, as residues of solvents used in the dope may carry oil from the varnish into the dope film and cause a relaxation of the shrinkage. [See p. 192.]

PREPARATION OF DOPES.

Nitrate of guncotton dopes are prepared from a guncotton of low degree of nitration dissolved in suitable solvents. The solvents consist of high boiling compounds with a boiling point higher than that of water, and low boiling solvents. Dilutents such as denatured alcohol and benzol are also used. High boiling solvents in common use are amyl acetate or butyl acetate, and the common low boiling solvent is ethyl acetate. If a low boiling solvent were used alone, the moisture produced by its evaporation would precipitate the cellulose ester in whitened areas over the surface of the fabric. This phenomenon is commonly known as "blushing." When a high boiling solvent is present, the moisture evaporates first, and a clear, transparent film results. An excess of high boiler, however, causes slow drying and slow shrinkage, or may prevent shrinkage entirely. The amounts of high and low boiling solvents used must, therefore, be carefully balanced.

Similarly, cellulose acetate dopes consist of the ester dissolved in mixtures of diacetone alcohol, or methyl ethyl ketone, the common "high boilers" methyl acetate or acetone, the common "low boilers," and diluents are added, such as alcohol and benzol. The acetate film, however, is inherently brittle, and in order to give it the strength and flexibility of the nitrate film, so-called plastics or plastic-inducing compounds must be added. These consist of high-boiling liquids or solids, such as benzyl alcohol, triacetin, benzyl acetate, triphenyl phosphate, and others, which combine with the cellulose ester and produce a solid solution.

Cellulose acetate requires for its production considerable amounts of acetic anhydride, and acetic acid. Its preparation is a highly developed technical art requiring exceeding precision and care. The cost of cellulose acetate and cellulose acetate dopes is therefore much greater than the cost of nitrate dopes. It is combustible but is not inflammable like guncotton, and may be rendered fire resistant by the use of triphenyl phosphate as a plastic.

As a rule, four or five coats of dope are applied to a fabric. Each coat is allowed to dry superficially before the succeeding coat is applied. With application of the dope, shrinkage begins, but the maximum shrinkage is not apparent until 24 hours after doping or until residues of any high boiling compounds have evaporated from the surface of the film. The temperature and humidity of the doping rooms should be carefully controlled to minimize any danger of blushing, about 75°F. temperature and humidity not exceeding 65 per cent being employed.

AN INTERESTING FABRIC.

It is needless to say that when a fabric has been doped, an increase in textile strength is observed, for we not only have the strength of the fabric, but also the strength of the dope film. There is usually an increase in strength of approximately 15 per cent after complete doping.

From the above it is evident that the most ideal fabric for an airplane is one which combines great strength with light weight and which is also capable of shrinking when doped. A great many experiments have been devised along this line to effect improvement and an especially interesting one is on a novel principle. Though the fabric was not completed for practical use, still the experimental samples showed some wonderful results. The principle involved was that a straight line is the shortest distance between two points, and that in a known line ten feet of a single thread has as much strength as twelve feet of the same single thread.

Upon this assumption, a cloth was made without being woven, that is to say, that instead of being woven the threads were cemented by means of a paper-like construction. In other words, it was a fabric made of two warps; one warp to serve as the warp threads, and the other warp placed so as to constitute the filling, with no binders between except a paper-like construction.

This gave a fabric of great strength which had the appearance of being woven. Naturally with a fabric of this character, a hundred yards of warp thread would make a hundred yards of fabric, while in the woven fabric, a hundred yards of warp would not give a hundred yards of fabric, owing to the take-up in weaving. Consequently, both fabrics having the same strength, the woven fabric would not have the same weight to give the same strength, but would have added to it the weight of the take-up in weaving of both warp and filling. Another advantage of this style of fabric is, that a straight line thread does not have to be stretched to the length of a woven thread in order to produce the necessary tautness, thus where the woven fabric would require five coats of doping, this fabric would be found to be thoroughly doped under two coats. However, five coats of dope must be used in order to increase the thickness of the dope film and thus insure its durability.

There is no doubt a great field for a fabric of this kind in other lines aside from those pertaining to aviation, but owing to the signing of the armistice, research work on a practical scale was abandoned.

TRANSPARENT FABRICS.

During the spring of 1918 there was a request to produce a fabric which could be camouflaged in a manner differing from the camouflaged fabrics then in use. A wing of a bee, being transparent when in flight, is difficult to see. Of course, part of this is due to the high speed of its wings, but the greater part is due to their transparency. Hence the problem came up that for efficient camouflaging of a plane while in flight, it should give as little shadow as possible, and that preferably its wings should be transparent.

According to newspaper accounts the Germans had brought out a machine of this type which could not be discerned during flight, except the position of its engine construction; but as far as covering went, it was transparent. According to information available on the subject, the details of the composition employed are very scant, but no fabric entered into its construction and it was probably made from a compound like casein molded into sheets like celluloid. The disadvantage of this, however, is that the surface would readily tear and would be brittle; hence, if shrapnel were to fall around it, it would probably put the machine out of commission.

In order to produce the effect in this country, a fabric was woven like a gauze, the threads of which were far apart; and at a distance of six feet one could observe objects through it distinctly, still the threads were extremely strong. These threads were prevented from slipping by means of doup weaving and woven with the same number of ends and picks per inch. A fabric of this sort covering the airplane will render it transparent, but this fabric as it stands is not practical, for it has absolutely no wind resistance, and the spaces would not take the dope, and if a film covered them it would not have enough strength, but this was overcome by superimposing a fabric over this called a false fabric. The fabric referred to above was made of heavy silk of corded yarn and proved to be very strong, while the false or superimposed fabric was made of the finest silk threads, with little strength but fairly closely woven. The silk being so fine, the false fabric was practically transparent, but when

*From *Textile World Journal*.

placed over the other and doped, gave a foundation to which the dope could adhere.

Owing to the similarity in the index of refraction of fabric and dope the silk when doped and varnished became invisible. The result was a transparent wing of great strength. This was also in the experimental stages when the armistice was signed, and though many samples were made on an experimental scale, it was not tried out on a plane. Doubtless improvements will be made along the lines of a transparent surfacing; but this was only a step in which to arrive at the ultimate result, and which may prove of interest in future developments.

The German armored tank, constructed wholly of metal, appeared in the skies in the latter days of the war and brought down a famous American ace. The value of such an airplane with wings constructed of corrugated iron is apparent, and for purely combat purposes this type will doubtless displace the types now used in any future war. But since the war is over, and airplanes are being turned to commercial and pleasure purposes, there will, doubtless, be numerous inventions which will not have in mind the purpose of rendering them efficient for combat, but for the safety and reliability of travel.

A Theory of the Flow of Water Over a Canal Weir

(*Continued from page* 183)

be added to the canal weir, in order to obtain the necessary level for irrigation in the canal above the weir.

For various reasons it would seem that in order to obtain a theory, the question of resistance to flow must be gone into.

When water flows from a still-water reservoir over a simple weir, there is no observable surface fall except at the weir itself, the surface is smooth and unruffled by eddies on the surface, consequently the flow is not inturbulent motion. The flow is what may be called non-sinuous throughout and the ordinary resistances seem to be absent. Force is, however, required to overcome the inertia of the particles that fall over the weir; fresh particles are constantly being moved, and work is constantly lost in overcoming the force of inertia, not only when the particles are first moved, but also when the velocity of the particles is increased. The water flowing over the weir may be said to do work in overcoming the resistance due to inertia. If it were not for this resistance the water would flow over the weir at a great velocity. The force of inertia on each particle is probably extremely small, but collectively considerable.

When the water flows over a canal weir, the water being in motion, the inertia due to the initial movement of the water has not to be overcome, and consequently the velocity at the weir would be increased; but the water flows towards the weir in turbulent motion, which must cease before the water can flow over the weir in non-sinuous motion. Little is known of turbulent motion except that it is due to eddies or puffs of water that start from the bottom layers of the flowing water and come to the surface at some distance down stream from their place of origin. If it is assumed that the draw of the weir stops the action of the puffs, by decreasing the pressure in front of the particles of the lower layers, of the flowing water and thereby increasing their velocity, there would be no greater resistance than that caused by increasing the velocity of the lower layers of the flowing water.

At the section in which the puffs cease to form, the velocity of the bottom layers of flowing water would increase considerably, and the layers above would still be under the influence of the resistance due to the puffs that start higher up. As the water flows towards the weir the puffs come to the surface, and less water is retarded by them, consequently the mean velocity of the water increases towards the weir. As the resistance due to turbulent motion ceases, the surface fall, which may be said to be required to overcome the resistance due to turbulent motion, will cease also. The resistance a little above the weir will be due to the puffs that still rise to the surface, and as there is no surface fall the water would come to rest if it were not for the draw of the weir.

The action of the water flowing over the weir may be shortly described as follows:

The draw of water flowing over the weir causes the resistance of the water, flowing in the canal, gradually to cease, which allows the velocity to increase from that of the canal to that of the weir, and gradually renders surface fall unnecessary. The surface fall being unnecessary, the bed is scoured out and the surface fall is increased all the way up to the canal reach, from the point where the surface fall commences to decrease.

This theory does not seem to give directly a formula, but it seems to show that the velocity of approach should be the velocity of the canal above the portion which is influenced by the weir, and that any experiments taken to obtain coefficients should not be made in troughs with hard unerodable beds which do not allow scour to take place, and prevent the natural change of surface fall above the weir.

In order to obtain the height required to be added to the crest of the weir, to maintain surface levels for irrigation, it is necessary to find out the distance from the weir where the surface fall commences to decrease. This would seem to be the distance the puffs travelled before they come to the surface, and would depend on the surface fall of the canal above the influence of the weir corrected by the depth, as, the less the depth, the less the distance travelled by the puffs in coming to the surface.

It is often assumed that scour is due to the velocity being too great, but if it were so in this case the scour would increase as the surface fall increased, consequently there would be no limit to the scour, and irrigation would be affected very much more than it is. The surface fall above a certain amount would also be impossible unless the bed was lined with unerodable material. The theory of the flow over a canal weir described above gives a limit to the scour, as when the water has scoured the bed sufficiently to obtain the natural surface fall, no further scour takes place. No theory would seem to be correct unless it gave a limit to the inevitable scour.

This theory of the water flowing over the canal weir necessitates a portion of the wetted sectional area being unrequired by the main stream of water flowing over the weir. This unrequired space is triangular in shape, being bounded by the bed, the face of the weir and the stream of water flowing towards the weir.

In this triangular space a current is formed owing to the reduced pressure caused by the high velocity of the water as it flows over the weir; this current flows towards the weir close to the main current flowing over the weir and in the same direction: at the weir wall it flows downwards, and there is a return current along the bed. This current is therefore continuous, and the same water flows round and round the triangular space; it is an entirely separate current to the main current, but it is practically impossible to find out the dividing line between the two currents, and consequently any attempt to measure the velocity of the main current of the water approaching the weir by means of current meters is not likely to be successful. The return current moves any particle of silt that may fall to the bottom along the bed to the place where the main current leaves the bed and commences to flow upwards, when the silt reaches this place the particles are lifted up into the main current in the same way as a piece of paper is lifted off the table by blowing over it. In the same way stones that may be rolled along the bed of the canal are lifted into the main current when they arrive at the same spot. It follows from this that if the lifting power is too small, the silt will remain and a deposit of silt will form.

The lifting power of the current will, according to Bernouilli's theory, increase with the square of the velocity of the main current as it leaves the bed, and the velocity of the current in the triangular space will vary with the square of the velocity of the water just before it passes over the crest of the weir.

The determination of the point where the surface fall commences to decrease, by means of surface measurements, is almost impossible; but as the point is just above where the main current leaves the bed, it is better to determine this point either by measuring the deposit of silt or else by observing the place where the particles moved along the bed are lifted up into the current. The latter method presents little difficulty if the observations are carried out in the clear chalk streams of Southern England.

Ultra-Violet Light in Field Signalling

Professor R. W. Wood, of Johns Hopkins University, Baltimore, gave to the Physical Society of London recently a demonstration of the uses of invisible light in warfare. The first device shown was a signalling-lamp, consisting of a 6-volt electric lamp with a small curled-up filament at the focus of a lens of about 3 in. diameter and 12 in. focus. This gave a very narrow beam, only visible in the neighborhood of the observation post to which the signals were directed. In order to direct the beam in the proper direction, an eyepiece was provided behind the filament. The instrument was thus converted into a telescope, of which the filament served as graticule. When directed so that the image of the observation post was covered by the filament, the lamp, when lit, threw a beam in the proper direction. In many circumstances the narrowness of the beam was sufficient to ensure secrecy; but sometimes it was not desirable to show any light whatever, and filters were employed to cut out the visible spectrum. By day a deep red filter, transmitting only the extreme red rays, was placed in front of the lamp. The light was invisible to an observer unless he was provided with a similar red screen to cut out the daylight, in which case he could see enough to read signals at six miles. By night a screen was used which transmitted only the ultra-violet rays. The observing telescope was provided with a fluorescent screen in its focal plane. The range with this was also about six miles. For naval convoy work lamps are required which radiate in all directions. Invisible lamps for this purpose were also designed. In these the radiator was a vertical Cooper-Hewitt mercury arc, surrounded by a chimney of the ultra-violet glass. This glass only transmits one of the mercury lines, viz., $\lambda = 3{,}660$ A.U., which is quite beyond the visible spectrum. Nevertheless, the lamp is visible at close quarters, appearing of a violet color, due to fluorescence. This gives rise to an apparent haze, known as the "lavender fog," which appears to fill the whole field of view. Natural teeth also fluoresce quite brilliantly, but false teeth appear black.

Reverting to the use of the lamps at sea, they are picked up by means of a receiver consisting of a condensing lens in the focal plane of which is a barium-platino-cyanide screen the full diameter of the tube. An eyepiece is mounted on a metal strip across the end of the tube. When the fluorescent spot has once been found somewhere on the screen, it is readily brought to the central part and observed with the eyepiece. The range is about four miles, and the arrangement has proved invaluable for keeping the ships of a convoy together in their proper relative positions by night.—*Nature* (London).

The Nitrogen Atom a Compound

Recent experiments with the alpha ray, originally detected by Rutherford and Dorn, have led to a discovery that nitrogen, which was first isolated in 1772 by D. Rutherford, and has for a century and a half been regarded and treated as an element, with an atomic weight of 14, is now suspected to be, not an element at all, but a compound of hydrogen and helium: the helium forming the central sun or nucleus of the system, the hydrogen nuclei appearing as satellites. The combining weight of 14 is explained as due to a central nucleus of three helium nuclei, each of mass 4, the remaining two being accounted for by the hydrogen satellites. It is an interesting coincidence that Dr. Dalton, according to the now accepted account, was first led to his ideas of the atomic structure of matter by a study of the physical properties of the atmosphere. Sir Ernest Rutherford, by experiments on the same gases, now sees in each of Dalton's atoms of nitrogen an atomic system in which two distinct elements play a part, while nitrogen itself, as an element, is apparently to disappear altogether.—*English Mechanic and World of Science.*

New Method and Apparatus for Measuring the Viscosity of Oils

The method and apparatus described by the author for measuring oil viscosities is based upon the law of Poiseuille, which governs the flow of oil through a capillary tube. The apparatus consists of a small pipette, to the lower end of which a short length of capillary tube is attached by fusion, and upon the upper and lower stems of the pipette are marks representing a definite and known volume of the oil. The upper limb of the pipette is formed into a funnel above this mark, and is closed with a rubber stopper through which passes a short length of glass tubing, which can be closed as required by means of a pinch-cock and rubber tube. The pipette is filled with the oil to be tested by suction, and after adjusting the level of oil to the upper mark, the pinch-cock is opened and the oil is allowed to run out until the lower mark is reached; the exact time required for this delivery of the measured volume of oil from the lower orifice of the pipette being carefully recorded. By surrounding the pipette with a small Liebig's condenser, through which a current of water is passing, the test can be carried out at any desired temperature. The equation based on the law of Poiseuille by which the coefficient of viscosity (V) is calculated is : $V = 0.003\ Tp$, where T is the time required in seconds for the discharge of the oil, and p is the difference in pressure at the beginning and end of the experiment. The above equation only holds, however, for a capillary tube which is 4 cm. in length and 0.15 cm. in diam., and for a pipette which measures 10 cm. between the two marks and has a capacity of 10 cu. cm.—G. Chéneveau, in *Jour. de Physique.*

Progress in Manufacturing Radio-Protective Glasses*

Characteristics of Glasses Lately Developed to Protect Against Ultra-Violet and Infra-Red Rays

By W. W. Coblentz, Ph.D., Assoc. Physicist, U. S. Bureau of Standards

THE old saying that it is an ill wind that blows no one good, is well illustrated in the manufacture of optical glass.

One of the chief requirements in the manufacture of optical instruments is a colorless glass. Iron is the most common substance which causes discoloration in, and hence diminishes, the transmission of optical glass. On the other hand iron impurities in glass have a marked absorption in the infra-red, the maximum being at about 1μ. This property may, therefore, be utilized in the manufacture of glasses for protecting the eye from infra-red rays.

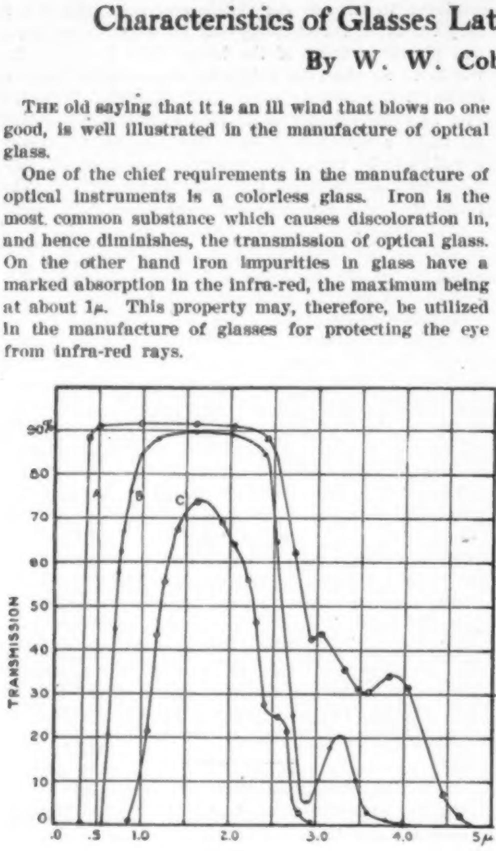


Fig. 1.

Although it has not been definitely proven that infra-red rays are injurious to the eye, there seems to be a feeling that protection from these rays should be provided. Fortunately this can be done easily and cheaply. And now the most pampered can be provided with glasses which not only give protection from rays which are known to be injurious, but also supply the most exacting demands as to color, etc.

It is of interest to consider the transmissive properties of various glasses which, used separately or in combination, protect the eye from injurious radiations —particularly from ultra-violet rays.

The ideal glass would be one which absorbs all the ultra-violet and infra-red, and transmits only the visible rays, by an amount sufficient to prevent irritation and injury to the eye.

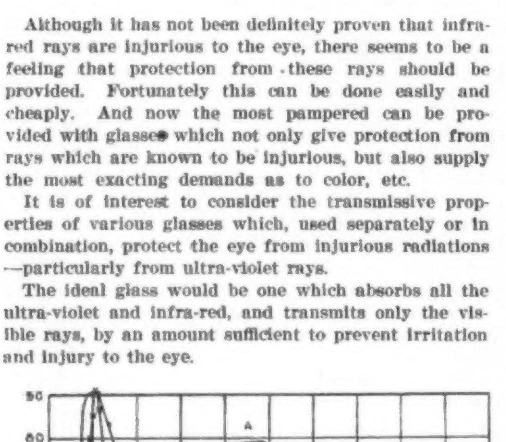


Fig. 2.

Four years ago the question of providing glasses for protecting the eye from injurious radiations was practically new and untouched. At that time the feeling was expressed that: "It appears as though in the near future glasses fulfilling every requirement will be obtainable, and it speaks well for American enterprise to be willing to spend a few dollars in attempting to produce devices for safeguarding the health and contentment of the public."[1]

In the meantime, this prediction has become a reality. The subject of eye protection has become national in importance, and manufacturers of eye protective glasses are meeting the most stringent requirements.

The variety of ways in which various manufacturers of eye-protective glasses fulfill these requirements, will be noticed in connection with the transmissive properties of various glasses, which will now be discussed. In most cases these glasses were about 2 mm. in thickness. More detailed data may be obtained by consulting the original paper.[2]

Colorless Glass.—It is of interest to note the characteristics of optically colorless glass. Curve *A*, Fig. 1, gives the transmission of a sample of white crown glass which transmits ultra-violet to about 0.3μ and infra-red to about 4.8μ. The shallow absorption bands at 2.9μ and 3.6μ are characteristic of glasses.

The presence of iron impurities produces a marked change in the transmission of a glass with an absorption band at about 1.1μ. This is illustrated in curves *A* and *C* of Fig. 2, which gives the transmission of window glass. Viewed edgewise, such glass appears tinged green.

Red Glass.—Curve *B*, Fig. 1, shows that red glass absorbs the ultra-violet and most of the visible rays. But it affords practically no more protection from infra-red rays than does clear glass.

Amber Glass.—As illustrated in Curve *B*, Fig. 2, amber glass absorbs the ultra-violet and some of the visible spectrum. Iron impurities produce an absorption band at 1.1μ. Aqueous solutions of iron alum have an absorption band at about 1μ.

Green Glass.—Curves *A*, *B*, and *C*, Fig. 3, show that green glass is opaque to the ultra-violet and has a wide absorption band in the region of 1μ. In combination with other glasses, it affords suitable protection from injurious rays.

Blue Glass.—Curve *A*, Fig. 4, gives the transmission of a sample of cobalt blue glass. In spite of the fact that blue glasses transmit ultra-violet, they are used in some high temperature work. Combined with a deep amber, red or green glass, it affords protection from injurious rays. For example, Curve *C*, Fig. 5, gives the transmission of a combination of several red and blue glasses used in arc welding. Curve *D*, Fig. 5, gives the transmission of a combination of a flashed red, a green and a blue glass used in oxy-acetylene welding. These two combinations were found to reduce the intensity of the visible rays by a suitable amount, and they afford proper protection from the infra-red and especially the ultra-violet. (In these two curves, *C*, *D*, Fig. 5, the transmissions are double the values indicated on the scale.)

Sage Green and Blue Green.—Two excellent glasses for absorbing the ultra-violet and infro-red are Crookes' ferrous sage green (Curve *B*, Fig. 4), and *C*, 124 *J.A.*, Curve *C*, Fig. 4.

Gold Leaf.—A thin film of gold on glass (obtained from *A.O.C.*; see Curves *A* and *B*, Fig. 5) eliminates the infra-red and ultra-violet, and by selecting the proper density provides also protection from visual rays.

Black Glass.—Ordinary "smoke" glasses are good for out-door wear, but they do not give sufficient protection when working near sources of intense ultra-violet radiation.

Judging from the small number of "black" glasses submitted for test, in comparison with other glasses used in oxy-acetylene welding and cutting, it would appear that the so-called deep "black" glasses are not used extensively.

Noviweld.—This is a commercial eye-protecting glass which effectively absorbs the ultra-violet and infra-red rays. The transmissive properties of various shades are shown in Fig. 6.

Dyes.—Attempts have been made to use dyed celluloid films instead of colored glass for protection against harmful radiations. In this manner it seems feasible to absorb the ultra-violet and visible rays. But the writer knows of no dye which has marked absorption throughout the infra-red. As shown in Curve *C*, Fig. 1, a sheet of celluloid which is dyed so as to be opaque to the visible and ultra-violet, is quite transparent in the infra-red.

The published data of others[3] shows that dyes (*e. g.*, green and violet dyes) which absorb the yellow and red become quite transparent in the infra-red. Hence, unless a dye is found which absorbs the infra-red, the outlook for substituting dyed films for colored glasses, for absorbing the infra-red, is not very encouraging.

The foregoing is a brief description of the characteristics of glasses readily obtainable, which singly or in combination afford protection from injurious radiations.

*Reproduced from *Journal Franklin Institute* (Philadelphia).
[1]Jour. Franklin Institute, May, 1913.
[2]*Bull. Bur. Standards*, 1918, *14*, p. 663.
[3]Pfund in *Zeitschr. Wiss. Photog.* 1913, *12*, p. 341; Johnson and Spence, *Phys. Rev.*, 1915 (2), *5*, p. 349.

A Gasoline Shunting Engine*

TWICE within comparatively recent times The Engineer has had occasion to refer to the gasoline railway vehicles manufactured at Bedford, and now again this same company has just brought out another novel machine. It takes the form of a shunting engine for

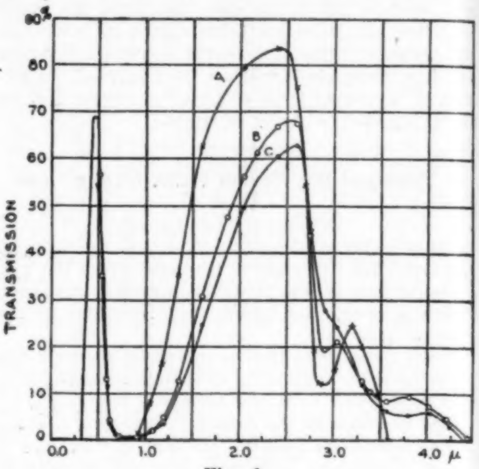


Fig. 3.

handling full-sized railway rolling stock, and is consequently much heavier than either the inspection cars or small locomotives which we have described in previous issues. The management of the Bedford firm came to the conclusion not long ago that there should be a demand for a petrol engine to take the place of the ordinary shunting locomotive used in the private sidings of many large works. Very soon it received orders for several such engines, and it was the first example to be put into service which we inspected last week at Bedford.

The locomotive, which is equipped with a petrol engine of 40 brake-horse-power, was at work, preparatory to being despatched to the purchasers in Scotland, and it was handling the usual traffic of the sidings under the charge of the normal shunting staff. It is

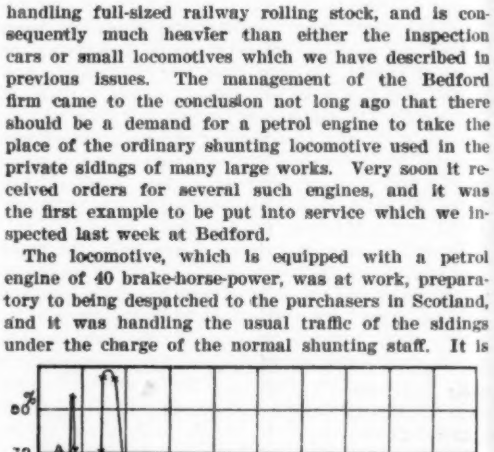


Fig. 4.

noteworthy, specially in view of the fact that the gasoline engine only requires one attendant, as against a driver and a fireman on a steam locomotive—which might be an excuse for antagonism on the score of a reduction of labor—that the siding men spoke very favorably on the behavior of the new machine.

It might be expected that when the clutch was engaged the gas locomotive would start off with a jerk and snatch badly at its load. Such behavior, however, seems to have been entirely eliminated, for we watched the engine for some time, and its starting compared as favorably with that of the usual type of tank engine as the starting of one of the old broad-gage Great Westerns with that of an American Express. As to capacity, the engine started from rest a load of 120 tons, and on another occasion took a load of six

*Reproduced from *The Engineer* (London).

trucks, and while it was drawing them over a short turn-out met and pushed ahead another set of trucks of about equal weight. We had no opportunity for testing the engine on a gradient, but the makers inform us that it will haul 7 tons up 1 in 40 at 12 miles per hour, or 17 tons up 1 in 20 at about 4 miles per hour. A characteristic in which the gasoline engine showed up to great advantage as compared with its steam-driven competitor, which was working in the adjacent railway sidings, was in the absence of smoke. The exhaust from the gasoline engine was hardly visible, while most works managers know what in insufferable nuisance a carelessly handled steam shunting locomotive can be in that direction.

There is only one feature of this gasoline engine in which it appears to us that any important improvement could be made, and that is in connection with the clutch, although, as we have already said, it picks up the load very smoothly. If the locomotive were pushing a heavy load and met with an obstruction, such as a stop block or long stationary train, the engine might be accidentally stopped and the driver would have to get down to "wind it up" again. If some device such as a slipping clutch could be introduced, or possibly a self-starter added to the engine, it would, we think, add greatly to its convenience.

Some idea of the general appearance of the new locomotive will be gathered from the accompanying engraving, from which it will be seen that it is of a good solid construction, and obviously intended for hard service. The engine and transmission are arranged on the same general lines as those of the armored locomotives which were described in "Engineer" of August 9, 1918—that is to say, the engine crank shaft runs thwartships, as also does the gear box.

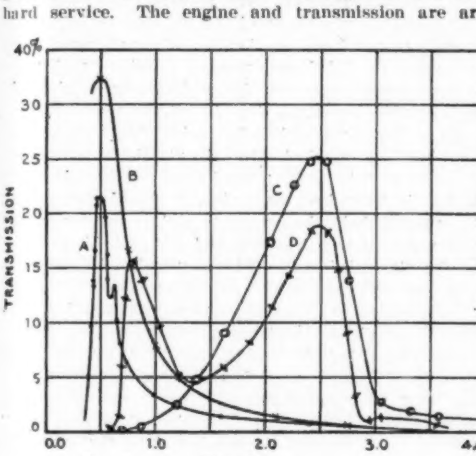


Fig. 5.

A pair of roller chains transmits the drive from the gear box to the axles of the driving wheels. The engine is of the four-cylinder type manufactured by Dorman's, of Stafford, and develops 40 brake-horse-power when running at 1,000 revolutions per minute. It is carried by channel cross-bearers between the side frames, which bring it to such a height that the cylinders come just above the floor plates. By swinging down the cover, which can be seen standing above the floor line in the center of the frame, the engine is exposed and the cover is substantial enough to act as a foot-plate while the engine is being inspected or adjusted. The gear box is below the floor plates, and thus leaves a good clear space for the driver. It is of the Dixon-Abbott patented design, which we have already described, and is manufactured at Huddersfield. In the case of the new locomotives an additional outboard ball bearing has been added to support the end of the shaft carrying the chain sprockets. The general arrangement of the clutch pedal, change-speed lever, throttle, &c., all of which can easily be reached by the driver from his seat, is similar to that adopted for the earlier and lighter locomotives, the system having proved to be so satisfactory that no alteration was called for. The driver, as he sits square in his seat, faces one side of the locomotive, and so has a good view in either direction ahead or astern by merely turning his head.

In order to take up the slack which must develop in the driving chains as they wear, the main driving axles can be moved in the horn plates a distance far enough to permit the removal of a link from the chain. The axle boxes have fore and aft movement in the horn

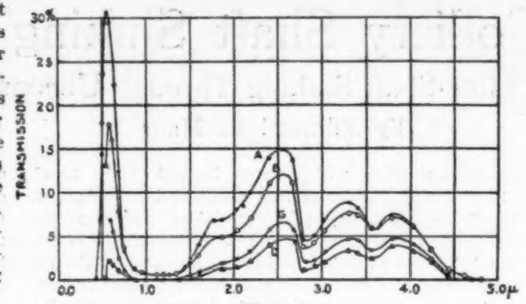
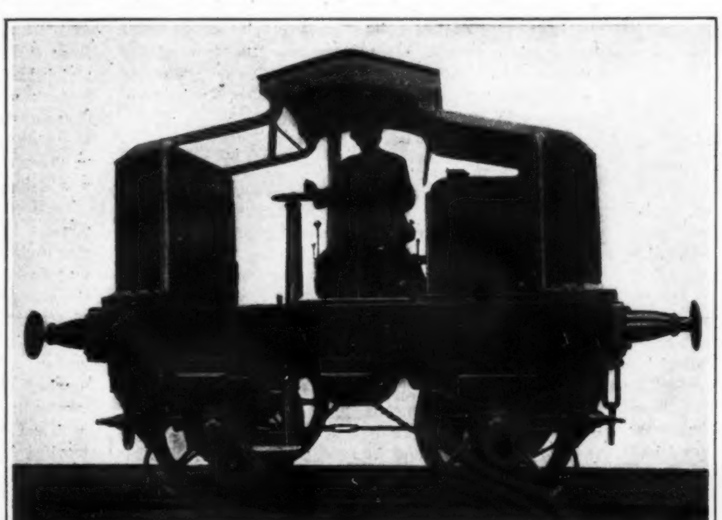


Fig. 6.

plates, which take only the side thrust. The end play is controlled by adjustable spring tension rods attached to brackets on the main frame, as can be seen in the engraving.

The side frames are built up of ¾ in. plating reinforced with heavy channel and angle sections, and the proportions generally conform to standard railway practice. There is, of course, ample opportunity to indulge in a substantial structure, as the propelling machinery does not provide nearly enough weight to give the adhesion necessary for the development of its tractive effort. It has, in fact, been necessary to add the two heavy cast iron end shields which form such a prominent feature in the engraving, to bring the weight up to the requisite amount of 8 tons.

The overall length of the locomotive is 13 ft. 4 in., and its maximum width 7 ft. 6 in. The height to the foot-plates from rail level is 4 ft., and to the buffers 3 ft. 4½ in. The wheel base is 5 ft. 6 in, which enables the engine to pass easily around the sharpest curve likely to be met on a siding, while the wheels are 3 ft. 1 in. in diameter, with journals 6 in by 2¾ in. The petrol tank holds 20 gallons, or enough to keep the engine running on ordinary shunting work for a day.


The latest gasoline shunting engine from England

Precious Stones in the United States

The value of the precious stones annually produced in the United States from the beginning of this century to 1914 has been about one-third of a million dollars. In 1914 and in every year since, the annual value of the output has dropped considerably, and in 1918 it dropped to $106,523, the lowest reported since the United States Geological Survey began to collect statistics of gem production, in 1883, with the single exception of 1896, when it was $97,850.

The report on the production of precious stones in 1918, just published by the Survey, ascribes the decrease in the value of the precious stones produced to the military enlistment of many gem miners, the general scarcity of labor, and the poor market.

The output consisted chiefly of the sapphire variety of corundum, which is nearly all used as mechanical bearings in watches and other instruments that require practically nonwearing frictionless bearings. Other less valuable and softer minerals used for this purpose are garnet and some forms of hard, compact silica, known as agate and chalcedony. The annual value of the output of the four gem minerals, corundum, quartz, tourmaline, and turquoise, amounts to over four-fifths of the total value of all the precious stones produced in the United States.

Montana, Nevada, California, Colorado, Maine, and Arizona are the chief gem-producing States, but from 20 to 30 States annually report more or less production.

Several relatively large diamonds were found in Arkansas in 1918, notably a canary-colored octahedron weighing nearly 18 carats and a number of smaller stones weighing several carats each. The value of all the diamonds produced in the United States, however, in no year exceeds a few thousand dollars.

The report also records the finding of two large diamonds in South Africa, weighing about three ounces each. It is estimated that about half the diamonds in the world are owned in the United States and that their value is over a billion dollars. With the elimination of competition from German Southwest Africa 95 per cent of the world's production of diamonds will be under the control of the De Beers Consolidated Mines Co. and its selling agents.

The report gives a short list of the industrial uses of precious stones of gem quality and full descriptions of the Iceland spar variety of calcite and of optical fluorite, states the special uses and necessary qualifications of the material, and includes lists of buyers.

The report on the production of precious stones in 1917 contains a full list of gem names, each followed by the name of the mineral species to which the gem belongs. A second list gives names of the mineral species, each followed by all the names of the corresponding gem.—*U. S. Geological Survey, Press Bulletin*, July, 1919.

Central Station Heating in Detroit

The general problem of the utilization of the heat ordinarily discharged to the condensing water in a central electric generating station is discussed. The impossibility of its complete utilization for the purpose of heating buildings and the difficulties in the way of even its partial utilization are pointed out, with particular reference to conditions existing in Detroit, Michigan.

The development of the central heating system of the Detroit Edison Company is traced, showing how the use of exhaust steam for heating was abandoned in favor of live steam. The reasons why it is more commercially expedient under the existing local condition to supply live steam to the heating system and to generate all electric current in the condensing stations are also fully brought out.

The paper also describes some interesting features of the central heating system in Detroit, such as the boiler plants, distributing system, underground construction of pipes and tunnels, consumers' installations and meters. Special mention is also made of distribution losses, condensation return lines, and the method of transmitting steam through feeders at high velocities and with large pressure drops.

The paper concludes with a discussion of the advantages of central heating service and of the obstacles to its wider use. It also points out the possibility of operating individual plants in combination with the central plant.—J. H. Walker (*The American Society of Mechanical Engineers*, Spring Meeting, June, 1919).

Making Cold Chisels

This article is of great practical interest to any engineers who are connected with workshops where work of a general nature embracing a good deal of hand labor is done. It is well illustrated with 27 figures, showing all the kinds of cold chisels in general use, and the purpose for which each particular type is best fitted.

The author describes the three forms of steel most suitable for cold-chisel manufacture—namely hexagon, octagon, and round-cornered rectangular. When parted off from the bar the chisel is heated on one end, and the head formed slowly rotating the blank and hammering the end until a conical shape is formed. The other end of the chisel is then heated for about 1½ inches of its length, and drawn down to a wedge-shape, great care being taken to prevent the ends spreading. To maintain the original hardness of the steel the chisel should be made in two heatings, and lightly hammered on the cutting edge as it is allowed to cool off on the anvil.

The author points out the importance of keeping both ends of the chisel in order, and explains the value of the thin cutting end and the correct cutting for various metals, such as steel, cast-iron and lead. The author emphasises the importance of correct grinding, and shows some common errors made in this direction. —*Coal Age, Power.*

Colliery Shaft Sinking*

Novel Method of Mine-Shaft Sinking Through Unconsolidated Strata

By Edmund L. Hann

The Chislet Colliery is situated on the north side of the South-Eastern and Chatham Railway, between Sturry and Grove Ferry stations, and is about five miles to the east of Canterbury. The results obtained from colliery enterprise in Kent up to the formation of this company in 1913 had been very disappointing from the view both of the time and money expended unnecessarily in sinking and equipping the collieries and also of the quality of the seams which had been proved. Consequently it was decided to proceed on comparatively modest lines, and, while providing for shafts and equipment to raise from 3,000 to 4,000 tons a day, yet not to spend such large capital sums as had been done in laying out the most modern and largest collieries in the old and proved coalfields.

The information available in 1913 as to the geology of this particular district was obtained from the Chislet Park and Stodmarsh borings, between which the proposed Chislet Colliery lay in an almost direct line, and from this information it was anticipated that the top of the coal measures would be reached at the depth of approximately 1,050 ft. These borings were carried out mainly for the purpose of proving the depth and extent of the coal seams, and the information available as to the exact nature of the intervening strata was not considered altogether reliable; therefore, before making any definite plans as to the method by which the sinking was to be carried out, it was decided to put down a control borehole near the site of the proposed shafts, in order to determine as accurately as possible the nature of the strata, and also the extent to which feeders of water might be expected. This control borehole was started on April 3, 1914, and was completed to a depth of 1,124 ft. by May 15, 1914. The information obtained showed that running sand was to be expected to a depth of 70 ft. from the surface, with a sandy clay for a further depth of 105 ft., and then 560 ft. of chalk with 336 ft. of gault immediately above the coal measures, the top of which was struck at 1,071 ft. The coal measures junction, which has caused much difficulty in previous sinkings in Kent, was free from sand and practically dry. The nature of the ground above the chalk indicated that the sinking through the running sand would be extremely difficult, while there was a certain doubt as to the nature of the sandy clay below it. It appeared that the danger of subsidence during this portion of the sinking would render the construction of engine-house foundations or heavy permanent buildings of any kind extremely hazardous until the shafts had passed through it, and consequently all such work had to be left until sinking operations in this ground had been dealt with.

DROP-SHAFTING.

The means of sinking considered were: (1) To freeze the ground and then line it with tubing; (2) to sink by the compressed air system; and (3) to drop-shaft, that is, to force a cylinder fitted with a cutting shoe through the sand. The first system had to be avoided if possible on account of the abnormal cost, and the second for the same reason, and especially owing to the discomfort to the workmen and its effect upon their health. The third system had the advantage of being cheaper and quicker, though there was little experience available of sinking to any considerable depth by this means. One of the greatest difficulties experienced had been to keep the cylinder vertical when large boulders or other obstructions had been met. The method of sinking followed in the two most notable cases where this system had been adopted had been the construction of a so-called "pressure-ring" of concrete or masonry work on the pit top, made of sufficient weight and strength to enable the cast-iron cylinder to be forced through the ground by means of hydraulic jacks, but difficulties had been encountered in constructing a ring which would stand the strain.

After full consideration it was decided at Chislet to replace the usual cast-iron cylinder by one constructed of ferro-concrete, which could be built up in short lengths as the cylinder sank; and further, instead of using hydraulic jacks for forcing the cylinder through the sand, to rely upon the weight of the cylinder together with such added weight as could be arranged. It was anticipated that there would be difficulty in the sandy clay below the running sand, though it appeared quite probable that sinking might be carried on from a depth of about 75 ft. by means of the "underhung" system continuing with concrete instead of the usual cast-iron ring. In order that sufficient latitude might be allowed for the cylinder not sinking truly vertical, the inside diameter was made 19 ft. instead of 16 ft., which latter was to be the finished diameter of the remainder of the shaft. Provided that the system described proved successful, the chief remaining difficulty to be expected was that very large quantities of water would be found at the top of the chalk, the indications in the bore hole showing that it was very heavily fissured, very spongy, and giving off very large quantities of water. This state of affairs applied more especially to the first 20 ft. of chalk, but there were signs that heavy feeders of water would be encountered for some considerable distance below.

SEALING OFF WATER.

The means by which it was proposed to seal off this water was by boreholes from the surface, penetrating for a distance of about 50 ft. into the chalk, into which cement under pressure was to be forced so as to fill the fissures and endeavor to render the ground more solid. The first work undertaken was to bore holes round the shafts at a radius of 6 ft. greater than that of the shafts, and with this object the ground was levelled and a sheet of concrete 60 ft. in diameter laid upon the site of each shaft for the purpose of enabling the boring plant to be moved from one hole to another without dismantling.

Boring was begun on May 29, 1914, and 12 holes were bored round the North Pit and 11 holes round the South Pit, each hole being 6 in. in diameter and bored to a depth of about 225 ft., or approximately 50 ft. into the chalk. The holes were immediately tubed and the tubes cemented in. Cementing was then done by means of a special pump with steel ball valves, and altogether 474 tons of cement were injected into the strata round the North Pit and 445 tons round the South Pit. Incidentally a certain amount of cement was injected into the sandy clay. The holes were bored in 20 ft. stages, cement being injected at each stage and the holes rebored. The maximum pressure used during this part of the cementation was 500 lb. per sq. in.

Immediately this work was completed the concrete sheets were removed and the sinking to water level, namely, to a depth of about 22 ft. below the surface, was proceeded with. This excavation was made sufficiently large to accommodate the 19 ft. diameter ferro-concrete cylinder, together with 9 in. by 3 in. deals, which were to act as guides for the cylinder or shaft casing while it was being dropped. In view of the pressure which afterwards was experienced owing to a subsidence it became necessary to replace the original timbering by ferro-concrete.

CONSTRUCTION OF SHAFT CASING.

The reinforcement for the shaft casing was built up in eight segments to the circle, and consisted of steel channels and flats riveted and bolted together; the outside of the casing was of steel sheets, the joints of which were welded by the oxy-acetylene process to make the casing water-tight. The cast-iron cutting shoe was made in eight segments, and when put together in the shaft was suspended by eight steel ropes, these ropes being of course surrounded by the concrete as the casing was built up. The suspension bolts were passed through clamps at the top of the shaft and were attached to screws 6 ft. long, which were fastened through the suspension baulks, with the nuts resting upon steel washers. By means of these screws it was a simple operation to level the cutting shoe and afterwards the shaft casing. After the cutting shoe was levelled the reinforcement was built up to the underside of the suspension baulks, the joints of the back sheets being welded as they were built up. The work in the shaft was done from a scaffold operated by four hand winches. The inside shuttering consisted of eight segments to the circle. Each ring was 3 ft. high and constructed of ¼ in. thick steel plates and 1½ in. angles, the angles being drilled for bolting together.

OBSTACLES ENCOUNTERED.

The concrete was filled in as each length of reinforcement and shuttering was built up, the thickness of the shaft casing being 12 in. As the concrete was filled in and the weight added, the casing was allowed to drop into the sand, but was controlled by the screws at the top of the shaft. When the concrete had been completed to the top and the casing had dropped until the ropes were slack—namely, a depth of 6 ft. 6 in.—the removal of the sand was started. This was done by means of a 5-ton locomotive crane and grab. As the grabbing proceeded the screws were lowered and the casing sank gradually. During the first 10 hours a distance of 3 ft. was sunk, but this rate was slower than it otherwise would have been owing to the fact that the sand was so fine that it leaked out of the grab until some alterations had been made, after which the speed of sinking was approximately 9 in. an hour until a depth of 60 ft. was reached, when no further movement could be obtained. It was then found that the cutting shoe had struck a bed of ironstone conglomerate about a foot thick. However, this bed was broken through by means of the grab and the lining then sank 3 ft. in about five minutes, through dark grey sandy mud, when it came to rest upon another bed of conglomerate. This bed was about 2 ft. thick and was consequently more difficult to break; in fact, the cutting shoe in piercing it broke it up into pieces 2 ft. long and 3 ft. square which were brought out in the grab. The casing then sunk another 3 ft. very rapidly when it came to rest upon another bed of conglomerate. At this point the subsidence referred to above took place and rendered necessary the replacement of the timbering at the top of the shaft by reinforced concrete.

Up to this time, although considerable quantities of sand had been grabbed out of the pit, the water was allowed to remain at its normal level, so that the shaft bottom had not been seen since grabbing commenced. In order to help the casing to sink, some water had been wound out of the shaft, and this probably accounted for the subsidence. The suspension baulks were then removed from the pit top, the ropes were cut off, and the casing was built up and concreted to a height of about 10 ft. above the pit top for the purpose of adding more weight, but the casing still did not move. The services of a diver were then engaged in order to find out what was obstructing the casing and if possible to remove it. His report was that there was about 3 ft. of sand around the cutting shoe, that the edge of it was resting upon rock, and that when he removed a portion of the sand it immediately began to run, and he was unable to do anything towards breaking the rock. At this point a 6 in. diameter tube was driven down through the ground at the center of the pit to endeavor to ascertain definitely the depth of the bed of sandy clay. The tube was driven down by means of a 30 cwt. pile-driven monkey to a depth of 96 ft. from the surface, when it was found that the ground which had been taken for clay in the boring was in fact a dark grey sandy mud, having all the objectionable characteristics of a true quicksand. It appeared probable, then, that this would extend to a depth of 190 ft. in the pit, and it was inevitable that the drop-shafting would have to be persevered with to this depth.

Before proceeding the guides were reset and the suspension baulks increased in size. In order to break up the rock encountered, the 30 cwt. pile-driven monkey was fitted with four steel teeth and was dropped round the side of the shaft by the crane, the drop being about 10 ft. At the same time additional weight was placed in the shaft by fitting 5 in. by 5 in. angle rings to the casing on which pine baulks were placed, bricks being stacked on these. The baulks were put 20 ft. apart, vertically, and 120 tons of bricks were loaded upon each set of baulks. After the pile-driven monkey had worked for some time and altogether 300 tons of bricks had been added, the casing began to sink again, but several obstacles were met in the shape of boulders and had to be removed by means of the monkey, though in no case was it necessary again to call for the services of the diver.

METHOD OF BUILDING UP REINFORCEMENT.

From the depth of about 60 ft. onwards, the suspension ropes and screws were not used, any tendency of the casing to get out of line being corrected by the way in which grabbing was done. In building up the lengths of reinforcement, the method adopted was that each ring was built up on a platform near the pit top to a depth of 5 ft., the vertical joints of the back sheets being welded; the whole ring was then lifted up by the crane and put into place so that there were only the vertical reinforcements to be bolted up and the horizontal joints of the back sheets to be

*Reprinted from *Times Engineering Supplement* (London).

welded. This work occupied only about 50 minutes. During the latter part of the sinking it was found advantageous to pump a certain quantity of water out of the shaft, which had the effect of causing the casing to drop faster than it would otherwise have done. When it had dropped to a depth of 106 ft. it became possible to pump all the water out of the pit, and it was found that the cutting shoe had penetrated a distance of 4 ft. into the sand. Practically all the water was thus closed off, while the sand was filled with cement veins, which seemed to have the effect of consolidating the sand to some extent, thereby making it into a form of very soft rock. From this point grabbing was abandoned and the ground was excavated by men at the shaft bottom. No particular defects were encountered and the shaft lining sank as the excavation proceeded. There were, however, one or two somewhat alarming outbreaks of water, and as the ground became harder the casing began to stick and on some occasions sank as much as 3 ft. suddenly.

At a depth of 130 ft. drop-shafting was discontinued and sinking was carried on by underhanging. The weight of the shaft lining at this point together with the bricks that had been added amounted to 1,057 tons. No particular defects were encountered in underhanging, but great care was required and the reinforcement had to be put in in lengths of 2 ft. 6 in. The sinking by this process was continued down to 203 ft., at which depth it was 7 ft. into chalk. In the South Pit, after the experience gained in the North Pit, the process was faster and the defects much more easily overcome. The total cost of sinking the two shafts from the surface to a depth of 201 ft. was £13,600, including the boring and cementing.

The next stage of the sinking could not be proceeded with until some heavier plant had been installed, as it was decided to do the sinking with a permanent winding plant and considerable time was necessary to prepare the machinery, etc.

CEMENTATION OF CHALK STRATA.

It will be gathered that so far nothing had been done in the way of cementing below a depth of 225 ft., while it was fully expected that the chalk to a depth of about 500 ft. from the surface would be heavily watered. One of the chief objections to the injection of cement during sinking in the past has been that it has been done from the shaft bottom in stages of about 50 ft. at a time as the sinking proceeds, with the consequent objection that at every stage the sinkers have to be taken out of the shaft while a length of boring and cementing is being done. At Chislet it was decided to utilize the time necessarily taken in erecting the plant by boring the whole of the ground down to a depth of 550 ft., and thoroughly cementing it. The way in which this was done was that by slight alterations made on the ground the crane was adapted for boring by the twisting rope system and a series of holes were bored from the bottom of each shaft, that is to say, from 220 ft. to a depth of 550 ft. Considerable boring speed was obtained by this means by a plant which was to a very large extent home-made. One of the features which enabled the fast boring to be done was that steel rails were attached to the rope in place of the usual boring tool, resulting in a very heavy weight being used and consequent heavy blow. At times there was a total length of 96 ft. of rail being used in the hole for boring and as much as 120 ft. was bored in a shift of eight hours. In the two shafts there was a total amount of boring of 5,805 ft., the amount of cement injected being 222 tons. The total cost of this boring and cementing with the exception of the cost of the boring tools and tubes, all of which latter were recovered, was £1,124. Large feeders of water were struck in boring, and in one case the water could not be dealt with and reached a height of 10 ft. above the top of the hole before it was closed down. The cementing was done in zones from the pit bottom downwards, each stage having to be rebored before proceeding to the next.

ADVANTAGES OF THE METHOD.

It seems clear that this method of cementing is altogether superior to that generally adopted, since it is possible to obtain very much greater pressures than is the case when only short lengths are bored, and at Chislet on many occasions a pressure of 3,000 lb. per sq. in. was used. The greatest difficulty encountered was boring through flints, but when the heavy rails were used this difficulty was considerably decreased. When the permanent plant was erected and sinking was resumed, it was found that the chalk was extremely heavily fissured, the size of the fissures varying from a hair's breadth up to over 2 in. in thickness, and that all the heavy feeders of water were shut off, the only water encountered being very slight bleeding through the pores of the ground. The sinking through the gault did not present any difficulties. The shaft lining throughout the whole depth was of concrete. In the solid ground no reinforcement was used, but in the gault, where the ground is apt to swell, reinforcement similar to that used during drop-shafting was put in. The chalk below a depth of 550 ft. and the gault was not expected to yield water and practically none was found. The shaft lining throughout the pits is watertight, and such small amounts of water as could not be cemented off are collected at the back of the lining and led into a water garland, so avoiding the concrete being subjected to any pressure while being built.

The whole of the work described, with the exception of the trial boring, was done during the war under considerable difficulties with practically no skilled labor and in many cases with unsuitable material, and in addition the work was subjected to continual interference and stoppage on the part of the Government; otherwise the pits might have been completed and have produced considerable quantities of valuable coal long before the end of the war in a locality where it was badly needed. The general equipment and lay-out of the colliery is on modern lines, but does not call for any special description.

The Electric Furnace

(*Continued from page 181*)

explicable only by the electrical theory of Haber & Koenig. The gases are cooled, oxidized, and absorbed in a similar manner to the above described processes.

In all these processes the yield is extraordinarily poor, equivalent to 70 grms. nitric acid per kilowatt-hour (about 3 per cent of the total heat expenditure). It is only the availability of cheap sources of electrical power (as water power) and the negligible cost of raw materials that have made the processes commercially feasible.

Their future seems to be along the lines indicated—the production of electrically activated nitrogen and oxygen and their combination in the "cold" arc. None the less, astounding developments have already taken place, and there seems to be a bright future indeed for a process at once economical and efficient.

Of the processes other than the arc process for the electrical fixation of nitrogen, the Serpek process is worthy of note. This has already been mentioned under the manufacture of aluminum. Besides this, the production of metallic cyanamides is of increasing importance. Calcium cyanide is produced by heating calcium carbide (in itself a product of the electric furnace) with atmospheric nitrogen. The heating element consists of a carbon resistor rod embedded in the mass. The reaction

$$CaC + N_2 \rightleftarrows CaCN_2$$

is started at about 1,000°C. After once starting the reaction in proximity to the resistor, the current is kept on until the process, which is exothermic, proceeds spontaneously. The whole time of absorption is from 30 to 40 hours. The calcium cyanamide is the well-known fertilizer "nitrolime" or "kalkstickstoff." By extracting the technical product with water, dicyandiamide is obtained. This compound is used in the preparation of dyes and explosives. Cyanamide is also used directly to replace sodium cyanide in the extraction of gold, and indirectly for the production of calcium cyanide. Cyanamide finds many other minor applications in the arts and sciences.

The Nitrogen Compounds in Rain and Snow

F. T. Shutt and R. L. Dorrance summarize the results of ten years' work on the nitrogen compounds brought to the earth by rain and snow at a station near Ottawa. A total of 65.8 lbs. of nitrogen per acre was furnished in this way in the ten years, made up of 34.1 lbs. in the form of free ammonia, 10.1 lbs. of albuminoid ammonia and 1.6 lbs. of nitrates and nitrites. The rain was caught in a tray 60 in. by 30 in. Every separate fall of rain of more than 0.01 in. was analyzed, while in the case of continuous precipitation measurements were made twice a day. During a period of severe drought when bush fires were prevalent in the neighborhood the scanty rain was particularly rich in free ammonia. Rain was found on the average to be approximately twice as rich as snow in nitrogen compounds, but the individual samples showed more variability with rain that with snow.—*Science Abstracts.*

Researches on Alloys Rich in Zinc

An account of experiments by L. Guillet and V. Bernard, made with the object of discovering a high-zinc alloy of approximately the same properties as 70/30 brass, namely, max. stress 28-32 kg.-mm.², elongation 25-30%, impact number 3-5 kg.m. The nearest results were obtained with an alloy of commercial zinc (Pb 1-1.2%) and 1.5-2% Cu which gave, when drawn into wire, a max. stress of 30-31 kg./mm.² and an elongation of 27-28% and with an alloy containing 8% Cu and 4% Al, which in the form of wire had a tensile strength of 36 kg./mm.² and an elongation of 24%. In all cases the resistance to impact was much less than that of a 70/30 brass. The tests given by the rolled alloys were far less satisfactory than those of the drawn samples. The micro- and macro-structures of the alloys are discussed and twenty micrographs given. Hardness determinations were made and portions of the thermal-equilibrium diagrams of the systems constructed. The best temperature for rolling and wire-drawing was discovered to be about 125°-139° C.—*Science Abstracts.*

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

Derivation of New Magic Squares

To the Editor of the Scientific American:

Re article in the Scientific American Supplement No. 2246, dated January 18, 1919, entitled "The 34 Supermagic Square": If the following method of deriving new squares is new it may interest some of your readers. I have not heard of it before. I take as an example a "five" square:

A 17	B 23	4	10	11
24	5	6	12	18
1	7	13	19	25
8	14	20	21	2
15	16	22	3	9

Original

In the above square:

"1" is the 11th figure counting from the top left hand corner. Put 11 in the first square *A*—"2" is the 20th figure, &c. Put 20 in the second square *B* and so on. We thus get a new square.

A 11	B 20	24	3	7
8	12	16	25	4
5	9	13	17	21
22	1	10	14	18
19	23	2	6	15

Derived

Another "65" magic square can be derived from the original by turning it through a right angle and proceeding as before. The same procedure can be applied to your "34" magic square. Wm.

Cold Storage of Food

(*Continued from page 178*)

By the second method the bacteria may reach the interior of the meat comparatively rapidly, and set up fresh centers of infection within the meat.[10]

Fungi produce a somewhat characteristic degeneration of the surface of the meat described as mouldiness.

The changes bringing about the deterioration of meat at ordinary temperatures are, then, chemical in nature. They are either brought about by the meat itself in conjunction with certain external conditions in regard to moisture and oxygen supply, or are the result of the action of micro-organisms (bacteria and moulds), living saprophytically on the meat. In the preservation of meat in cold storage the object is, of course, to prevent these changes as far as possible.

In considering how low temperatures influence these processes we must treat of chilled meat and frozen meat separately, as the problems involved are quite different in the two cases. Chilled meat is usually stored at temperatures from 0° to 3°C. At these temperatures all the changes which take place at higher temperatures also take place, but at a reduced rate. As in the case of fruit, scope for variation in the method is not great. The external factors which can be influenced are again light and humidity. As regards light it is generally held that meat should be kept stored in the dark, as the presence of light accelerates the actions resulting in rancidity of the fat. In regard to humidity a moist atmosphere favors the growth of bacteria, while later, moulds appear on the surface of the meat in abundance. On the other hand, if the atmosphere is dry, water is lost from the meat by evaporation, but it is regarded as an advantage if the surface of the meat is harder and drier owing to water loss, as it renders the penetration of micro-organisms slower and more difficult.

Thus the principle involved in the preservation of meat at low temperatures above the freezing-point is the reduction in the rate of progress of a number of chemical actions. It is obvious that the changes leading to deterioration of the substance are not stopped, but are only slowed down, and consequently there is a limit to the time in which meat can be kept in this way without substantial deterioration. For sides and quarters of beef this limit is about thirty days, although sometimes the produce is kept for twice this time, or even longer.

When meat is preserved by freezing the case is quite different. It is stated that if the meat is frozen to — 10°C. the growth of bacteria is absolutely prevented, since this cannot take place in a solid medium, while the chemical actions proceed at a negligible rate. Hence, frozen meat can be kept without deterioration for a much longer time than in the chilled condition; frozen beef can be kept for three years, or even more, without reduction in its nutritive value.

The physical changes taking place in freezing are those connected with the water relations of the tissue. As is well known from the appearance of frozen meat, water which was formerly bound in some way becomes free. This is particularly the case with beef, in which the amount of water lost under certain circumstances can be very considerable. For instance, Ascoli and Silvestri[11] mention a loss of 15 to 20 per cent of the fresh weight of the meat. The juice which runs out contains valuable nutritive substances[12] and the quantities which can be lost in this way may be very considerable. The keeping qualities after thawing may be much reduced by this behavior. Nevertheless, Gautier[13] found the composition of frozen meat the same as that of fresh meat, or that it even had a higher nutritive value on account of the water loss. As regards beef this process is to some extent reversible if careful thawing be applied.[14]

It seems very desirable to have an official gradation of frozen meat based on such an essential property as this binding of water.

In the concluding article we shall deal with the question as to the conditions under which these irreversible changes in regard to water relations can be minimized or avoided.

[10]Richardson and Scherubel, *J. Ind. Eng. Chem. 1*, 95, 1909.

[11]See summary in *Le Froid*, Paris, Jan. 1914.

[12]W. Storp. *Uber Gefrierfleisch, Veröffentl. aus d. Geb. d. Militär-Sanitätswesens*, Heft 55; *Arbeiten aus d. hyg.-chem. Untersuchungsstellen*, VI. Teil, 51-73, Berlin, 1913.

[13]A. Gautier, *L'Alimentation et les régimes chez l'homme sain et chez les malades*, Deuxième Edition, Paris, 1904. See also Richardson and Scherubel, "The Deterioration and Commercial Preservation of Flesh Foods," *Journ. Amer. Chem. Soc.* 1908, *30*, 1515-64.

[14]W. D. Richardson, "The Cold Storage of Beef and Poultry," *Premier Congrès International du Froid, Rapports et Communications*, vol. *2*, pp. 261-316, Paris, 1908.

Problems of Airplane Fabric Preservation

An account of a long series of researches on the causes of, and methods of preventing, deterioration in linen airplane fabric, was given by Dr. F. W. Aston before the Royal Aeronautical Society.

At the beginning of the war little had been published concerning the functions and weathering properties of dope. It was known that on exposure the dope of doped fabric cracked sooner or later, and it seems to have been generally believed that deterioration of both strength and tautness was due to such cracking. As it was expressed at the time, "the dope cracked and let the weather get through to the fabric." Though more or less correct as regards tautness, which is a function of the dope layer principally, this idea is now known to be entirely wrong as regards strength, which is chiefly due to the fabric. Energies were, therefore, largely directed to the preparation of flexible varnishes which would prevent the cracking of the dope layer.

When opportunities of examining old machines became more frequent, it was noticed that at points where the dope was covered with an opaque layer of paint, such as the number on the tail and the identification disks on the wings, the fabric retained great strength, although the unpainted parts might tear like paper. This suggested that the real cause of the weakening was light, a conclusion since abundantly justified. The dopes with which these results were noted were made with tetra-chlorethane. As that compound is decomposed by sunlight, it is quite possible that the real agents that destroyed the linen were the chlorine and the hydrochloric acid liberated. In time the action of light was seen to be more direct and fundamental. The abolition of the use of tetra-chlorethane for other and better-known reasons made little if any difference in the rate of deterioration, and long before the real causes were discovered practical prevention was achieved by a pigmented varnish of a dark khaki shade known as P.C.10. Experiments extending over three years confirmed the view that the deterioration in the strength of doped or undoped linen fabric under ordinary service conditions is due to light and to light only, the effect of other agents such as heat, moisture, bacteria, molds, etc., being inappreciable in comparison. Visible light had little if any destructive effect, but in the direction of the shorter wave lengths there appeared to be no limit. As ozone and peroxide of hydrogen have long been suspected of being the principal agents in the deterioration, experiments were made in which oxygen and water were partially or wholly eliminated. It was concluded that the removal of oxygen from the atmosphere surrounding the fibers largely reduced but did not eliminate the destructive action of light, while the presence or absence of moisture did not seem to be important.

At the time when the investigation of the best method of protection was started, it was not thought possible to pigment a dope without spoiling it. Experiments were, therefore, made with dyes, and out of about 150 soluble in dope half-a-dozen or so gave promising results, two blacks and one yellow affording practically perfect protection and not fading. Raftites containing only 1 per cent of such dyes gave a decrease in strength of less than 15 per cent over 12 months' continuous exposure, that is, were as good as P.C.10. Had strength alone been of importance dyed dopes would have been advocated, but tautness was equally essential, and the possibility of its deterioration being also due to the action of light and therefore to be minimized by dyes was not realized. In addition Dr. Ramsbottom discovered that raftite, which contains no tetrachlorethane, could be successfully pigmented and that such pigmentation enormously improved the qualities of the dope as regards tautness.

A pigment used for protection in either a varnish or a dope must have a high extinction coefficient for actinic light, must be capable of being ground extremely fine, since a given weight of pigment will cover an area directly proportional to its fineness, and must be chemically inactive to any of the constituents of the medium. The natural oxide of iron known as ochre possesses all these properties to a notable degree, and in view of its cheapness and of the fact that with the addition of a little lamp black it yields a khaki shade, it is not surprising that its use as the main constituent of pigmented varnishes and dopes is almost universal. For tropical work aluminum has much to recommend it.

The Germans do not seem to have adopted pigment varnish as a protection from light. Experiments were made on fabric taken from a practically brand new Albatross scout plane. The fabric appeared to be flax, rather coarse, open and highly calendered, and was camouflaged with highly-colored hexagons dyed on the fabric before doping. The dope was acetyl without protective varnish. The effect of exposure to the equivalent of about three weeks of summer weather was surprising. The condition of the German dope was hopelessly bad.

Dr. Aston pointed out that tautness is aerodynamically essential to reduce the sag to certain limits, though with the materials now in use probably any surfaces deteriorating to a slackness sufficient to affect the aerodynamical properties of the machine seriously would have been condemned long before on their appearance. Another point which has been somewhat neglected is the great extent to which the strength of the wing structure is influenced by the tension of the doped fabric upon it. In general slackness of the dope will weaken the wing structure, but on the other hand too great tautness will lead to deformation or even fracture.—*Times Engineering Supplement* (London).

SCIENTIFIC AMERICAN SUPPLEMENT
Founded 1876
Published by Scientific American Publishing Co.
New York, Saturday, September 20, 1919
Munn & Co., 233 Broadway, New York
Charles Allen Munn, President; Orson D. Munn, Treasurer
Allan C. Hoffman, Secretary, all at 233 Broadway

The Scientific American Publications
Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) 5.00
The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.
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